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A COMPARISON OF VARIOUS LESS LETHAL PROJECTILES

Ellsworth B. Shank, et al

Army Land Warfare Laboratory
Aberdeen Proving Ground, Maryland

June 1974

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The report presents an analysis of measured physiological effects resulting from impacts of several different types of allegedly less lethal projectiles. The analysis gives indications as to which projectile characteristics tend to correlate most highly with damage and which critical parts of the body are most susceptible to damage/undesirable effect from the various projectiles. In addition, some preliminary findings are given as to what characteristics tend to optimize a "kinetic-energy" dispersal weapon.

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A COMPARISON OF VARIOUS LESS LETHAL PROJECTILES

Final Report

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June 1974

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DISTRIBUTION UNLIMITED

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I. INTRODUCTION

One purpose of this report is to bring together all the basic data collected by LWL in the conduct of physiological testing of less lethal devices. However, the major objective in writing this report is to present an assessment of the meaning of the data collected and present any findings which will aid in the design and evaluation of less lethal weapons.

The emphasis here is not on the overall evaluation procedure but focuses primarily on the physiological effects and, consequently, mainly on the "undesirable effects of less lethal weapons. Although an effort will be made to make this report useful without referring to other reports, it is inevitable that certain jargon and inbred concepts will be used; hence, it is recommended that the reader examine "A Multidisciplinary Technique for the Evaluation of Less Lethal Weapons (Volume I)"[1] which gives considerable background discussion on the evaluation of less lethal weapons.

The type of physiological effects examined in this report are generally classified as blunt trauma as opposed to penetrating trauma. However, in certain of the devices tested, especially the smaller projectiles at high velocity, there were some fairly deep tissue penetrations. Hence, we cannot be constrained to blunt trauma discussions only, but to the effects of allegedly less lethal impacting projectiles in general.

An alternative way of stating the nature of this study is that it investigates the relation between kinetic energy of impacting projectiles and damage to living tissue. It has been widely assumed that tissue damage is related to the kinetic energy of the projectile.

Although the emphasis of the report is placed on physiological response to impacting projectiles, some consideration will be given to the choice of an "optimum" projectile for achieving certain objectives using "nonlethal" (less lethal) weapons.

[1]Egner, D. O., Shank, E. B., Wargovich, M. J. and Tiedemann, Jr., A. F., "A Multidisciplinary Technique for the Evaluation of Less Lethal Weapons (Volume I)," USALWL draft report, July 1973 (to be published as a National Institute of Law Enforcement and Criminal Justice Monograph in 1974).

II. ANALYSIS OF THE TESTS

A. Measures of Physiological Effect

Three measures of the physiological response of animal organisms to the effects of so-called "nonlethal" weapons have been used in the investigation. All three have been developed for LWL's evaluation of less lethal weapons. Two of the measures are independent measures of well-being, whereas the third is primarily an auxiliary measure of well-being.

The first measure is the damage level grading system. The gross tissue damage to certain body areas and organs is ordered on the basis of a set of criteria which differentiates tissue damage on the basis of increasing severity. Any of six different levels of damage (0 through 5) may be assigned for a given impact. A value of "0" denotes no visual change to an area or organ, and a value of "5" denotes a complete disruption of the tissue in the particular area or organ. In the necropsy associated with specific tests, a number of "sharp" color photographs are taken of the affected area, and these photographs become the basic data utilized in the assignment of grade levels. (Details of the testing procedure, the accompanying necropsies and the Medical Group assessments are given in References 1 and 2). Actually, the damage level grades represent nine different submeasures, since there are sets of criteria for nine different body areas and organs, viz., head (brain-skull), heart, lung, liver, kidney, spleen, other viscera, bone, and skin/subcutaneous tissue/muscle. The specific criteria for each grade and each area are given in Appendix A.

The second measure of physiological effect is the probability of an undesirable effect (P_{UE}). In this measure, the Medical Group examines the same color photographs used in determining the grade levels, but the specific nature of the wound (along with any other information* on the animal's condition) is taken into account to assign a probability of an undesirable effect. An undesirable effect is defined as follows:

> that anatomical and/or functional effect which persists longer than 24 hours and prevents an individual from performing routine daily tasks and/or produces permanent impairment as defined by the American Medical Association (AMA) ratings.

In comparing these first two measures of physiological effect, the latter measure (P_{UE}) is felt to be more highly correlated with the well-being (or lack of well-being) of an individual subjected to a particular wound. In fact, the P_{UE} (probability of an undesirable effect) value also takes into account the

[2]Zelina, R. S. and Tiedemann, Jr., A. F., "Evaluation of the Physiological Effects of High-Q Spheres Impacted Against Laboratory Animals (Volumes I and II), USALWL Technical Report No. LWL-CR-07B72, August 1975.

*This includes the actual damage levels assigned, EKG information, death or survival of the animal, volume of blood in the cavity, etc.

difficult problem of scaling, that is, the transfer of information on a species of test animal to the effects on a human. One of the disadvantages of the P_{UE} value is that it is judgmental and requires a group of medical specialists to provide technically acceptable estimates. Furthermore, the tissue damage levels are much more specific and the mechanics of tissue disruption through kinetic-energy impact or blunt trauma are more understandable than the relation between systemic abnormalities and kinetic-energy impact.

Looking at the two measures in another way, there is reason to suspect that tissue damage levels and kinetic energy (along with other projectile parameters) will provide a relatively precise relation, whereas P_{UE} provides the more meaningful data for evaluating the hazards of impacting devices. At this point, however, it is worthy of note that for many of the organs and body areas graded there is a high degree of correlation between the two measures, damage levels and P_{UE}.

The third measure of physiological effect is the electrocardiograph (EKG) grading system. The EKG was first introduced into the tests to provide a better understanding of the animal's preimpact and postimpact cardiac conditions. However, several impacts were observed where the EKG indicated serious abnormalities in the cardiac function after impact but where the gross tissue damage to the heart was small. Since the heart appears to be a much tougher organ (i.e., less subject to tissue damage than the other organs examined for given kinetic-energy levels), it appeared that gross tissue damage levels for the heart should be augmented with additional quantitative information which would be more sensitive to kinetic-energy impacts than tissue damage levels. Hence, EKG grade levels were established by the cardiologist of the Medical Group as an auxiliary quantitative measure of the damage induced on the animal subject. To date, no separate analysis has been made using the assigned EKG grade levels, so the EKG grades are excluded for the present from the physiological data base in Appendix B.

Some further comments on the damage grade levels are in order. When we attempt to measure with a linear scale the amount of tissue damage induced, there is no denying the value of the attempt. We can quote classical statements from the history of science which say, in effect, that we cannot really understand a phenomenon until we can measure it. What is contestable, however, is the validity of the scale. Since we know of no other scale of physiological response which measures tissue damage, it suffices to show that the damage level scale has some positive merits.

First, the grades are meaningful in the extreme, i.e., Grade 0 indicates no observable tissue damage, whereas Grade 5 indicates extreme disruption of tissue. The intermediate grades are defined such that intermediate damage is ordered. For example, we can always say that Grade 2 is between 1 and 3, as opposed to saying only that Grades 4, 3, 2 and 1 are all somewhere between 0 and 5. In technical terms, we can say that the grade levels represent an ordinal scale.

The real question then is do the changes in grade represent constant intervals of damage? A rough observation of accumulated grades (Appendix C) shows a reasonable distribution of grade levels between 0 and 5. This does not validate a constant interval between grades, but any unusual (frequent or infrequent) intermediate grade may indicate a case of improperly weighted grade intervals. In fact, several cases of unusual intermediate grades do occur; but, rather than pointing out a deficiency of the grading system, these cases are medically interesting. For example, there is only one Grade 1 for the liver for all of the projectiles fired into the liver area, but there are nineteen Grade 0's and eight Grade 2's. Looking at the liver-grading criteria (Appendix A), this means there was only one case of a liver injury where the only damage was a subcapsular hematoma; whereas, there were eight cases of subcapsular hematoma with a simple fracture (less than one centimeter deep and/or less than five centimeters long). Another obvious nonuniformity is the relatively small number of cases of Grade 4 damage to the skin, subcutaneous tissue and muscle (treated as one body area). Essentially, the difference between Grade 4 and Grade 3 for a skin area impact is that Grade 4 involves laceration of fascia, muscle and/or fat, whereas Grade 3 involves no lacerations. The difference between Grade 5 and Grade 4 is that Grade 5 includes laceration of the skin. A further examination of the data shows that all cases of low frequency for Grade 4 occur with the four smallest-diameter missiles, whereas the three largest-diameter missiles result in Grade 4 frequencies which appear consistent with the accompanying Grade 3 and Grade 5 frequencies. Physiologically, this indicates that severe damage below the skin will be accompanied generally by laceration of the skin for smaller missiles; but for larger missiles, skin lacerations need not be expected with lacerations below the skin.

Before getting into the analysis of the data, a comment is in order on the composition of the Medical Group whose efforts were essential to this whole program. Whenever a medical group is assembled to provide a critical input to an investigative effort of this type, there is frequently a great "to-do" about the qualifications of the participants. Furthermore, since much of the activity of a medical group involves the exercise of medical judgment, there is a tendency to want an average of judgments from many different experts. The overall evaluation group approach to this problem was to assemble a few experts from the Baltimore area and indicate to them the basic objectives of the program. Then as part of a small team, rather than as separate independent medical experts, this group was asked to propose procedures for achieving the objectives that were the responsibility of the Medical Group. The proposal, which was accepted, consisted of a small working group of different medical specialists, viz., a forensic pathologist, a surgeon shock-trauma specialist, a cardiologist, a veterinarian-pathologist and a physiologist. This group's main function is to review assignments of damage grade levels, synthesize measures (or scales) of physiological response and provide estimates of P_{UE}.

B. Analysis of the Damage Level Information

A series of tests against animals was conducted by LWL, beginning in December 1971 with the testing of a high-energy rubber sphere (Superball) as a less

lethal projectile. Although less lethal tests had been conducted by LWL previous to December 1971, the earlier tests were much more limited in scope, and the basic data collected was primarily information on skull fractures. The tests discussed in this report are listed in Table I bel , and some characteristics of the items tested are given in Table II. The references[2-7] listed in Table I refer to footnote references given in this report. In some cases, the references give added information on the physiological tests; in other cases, they give results of accuracy tests and other types of engineering data for the particular device.

In the discussions that follow, there are 49 basic combinations of interest resulting from consideration of seven different body areas and/or organs graded against seven different projectiles, viz:

Body Area	Projectile (Test Series)*
H - Heart	S - Superball (Series 0, 100, 200)
L - Lung	B - Stun-Bag (Series 300)
K - Kidney	W - Waterball (Series 400)
LV - Liver	P - Ping Pong Ball (Series 500)
HD - Head (Brain)	M - Paintball (Series 600)
SB - Skin, Subcutaneous Tissue, Muscle (Body)	R - Ricochet Round (Series 700)
SH - Skin, Subcutaneous Tissue, Muscle (Head)	V - RTV Round (Series 800)

*It is emphasized that each projectile was considered against each of the seven different body areas listed in the left-hand column.

The test data from the seven different projectiles are summarized in Appendix C where damage levels are presented as a function of grouped kinetic energy values. For example, for the Superball/lung combination, an entry of 2 in the

[3] Zelina, R. S., "Analysis of the High Energy-Q-Sphere (Superball) Impacted Against Laboratory Animals (Low Lethality)," AAI Corporation Engineering Report ER 6923, March 1972.
[4] Sarvis, J. W., "Less Lethal Ammunition for Small Arms (Feasibility)," USALWL Technical Report No. 74-17, June 1974.
[5] Sarvis, J. W., "Less Lethal Liquid Ball," USALWL Technical Report No. 74-18, June 1974.
[6] Wargovich, M. J., Zelina, R. S. and Tiedemann, Jr., A. F., "Evaluation of the Physiological Effects of Stun Bag Projectiles," AAI Corporation Engineering Report ER 7351, July 1973.
[7] Franer, D. B. and Monson, F. A., "Ballistically Operated Water Cannon," USALWL Technical Report No. LWL CR 04M72A, May 1974.

TABLE I

LESS LETHAL WEAPONS EVALUATION TESTS PERFORMED BY USALWL

Test Series	Item Tested	Ref No.	Animal Species Baboon	Animal Species Swine	Animal Species Goat	Sponsor
0	Superball I	3	4		21*	Army
100	Superball II	2	18	18		Army
200	Superball III	2	7	19		LEAA
300	Stun-Bag	6	25	25		LEAA
400	Waterball	5	16	32		Army
500	Ping Pong Ball	5	23	37		Army
600	Paintball	5	22	32		Army
700	Ricochet Round	4	20	32		Army
800	RTV Round	4	22	34		Army
900	Portable Pumping System	7		20*		Army

*Not included in data base (Appendix B)

TABLE II

DESCRIPTION OF DEVICES TESTED

Item	Weight	Composition	Configuration	Dimension(s)
Superball	11.5 gm	High-energy rubber	Sphere, Solid	1.09" dia
Stun-Bag	av 190.5 gm	Fabric-covered bag filled with metal shot	Flat Disc, Flexible	3" dia
Waterball	av 263.7 gm	Soft plastic shell filled with a 40% glycerin & water solution	Sphere, Bursting	3" dia
Ping Pong Ball	av 29.8 gm	Hard celluloid shell filled with a 40% glycerin & water solution	Sphere, Bursting	1.375" dia
Paintball	3.2 gm	Soft plastic shell filled with oil-base paint	Sphere, Bursting	0.625" dia
Ricochet Round	8.2 gm	Clay-like substance, similar to "Silly Putty"	Cylinder, Pliable Solid	0.75" dia x 0.75" long
RTV Round	17.0 gm	General Electric silicone elastomer	Sphere, Break-Up	1.25" dia

Damage Level 4 row in the column for 75 ft-lb kinetic energy means there were two shots graded Damage Level 4 for kinetic energy of impact between 60 and 75 ft-lb. The basic data for each shot, along with most of the results of interest, are given in detail in Appendix B. The data in Appendix C (grouped by kinetic-energy bands) give only those grades for the area impacted, whereas the detailed shot data in Appendix B give individual kinetic energies and grades for all areas affected. In the analysis of damage level vs kinetic energy which follows, although based on Appendix B, only one area (or organ)--the one impacted--is associated with the damage level. The same shot, however, may be used in several relations, e.g., a thorax shot will yield a heart grade, a lung grade, and a skin grade; all other shots will yield just two grades, i.e., the underlying organ grade and the skin grade.

A cursory examination of the grouped data in Appendix C indicates that there are many instances where there is quite a spread in damage level grades as impact kinetic energy varies. Consequently, it appeared that the most significant and useful analysis of the data would be to approximate the physiological response by a linear least-squares fit. Hence, the least-squares fits were calculated (based on the basic data in Appendix B rather than the grouped data of Appendix C), and the results of this effort are given in Table III.

Obviously, the nature of these linear fits is influenced by several characteristics of the basic data. First, damage level grade can take on only one of six values (0, 1, 2, 3, 4, 5); hence, there is a limit to the precision of the fit due to the large intervals between different physiological responses. Second, the kinetic energies of impact were primarily in the region from 30 to 90 ft-lb; this limited range provides some linear fits which are somewhat distorted for those projectile/body area combinations which are relatively insensitive in the 30-90 ft-lb range. This will be discussed in more detail below.

The combination of the Ping Pong Ball projectile and the heart damage levels is selected as an example of the linear fit between damage levels and kinetic energy. The information is presented in Figure 1; i.e., both the data points from Appendix B and the linear least-squares fit to these data are presented in Figure 1.

In order to provide some comprehension of the overall results of these experiments in a single picture, the 49 linear least-squares fits are plotted on one graph (Figure 2); but, in order to avoid the appearance of a mass of 49 lines, each line is represented by a point. That is, in Figure 2, each linear least-squares fit is represented by a point, the abscissa of which is the slope (m) of the line and the ordinate of which is the y-intercept (b) of the line; for example, the line of Figure 1 is represented in Figure 2 by the circled point P-H (.00874, -2.324).

Some orientation of this technique of presentation is provided by the two lines on Figure 2 which bound all but two of the data points. The points of the upper line represent a ray of lines going through the 90 ft-lb, Damage Level 5 point for data presentation of the type given in Figure 1. The points of the lower line represent a ray of lines going through the 40 ft-lb, Damage Level 0 point. If the two lines were extended, their point of intersection

TABLE III

LINEAR LEAST-SQUARES SUMMARY OF THE DATA

Projectile	Area Impacted	Intercept, b	Slope, m	Correlation Coefficient, ρ	Sample Size, N
Superball	Heart	2.149	0.014	0.196	9
	Lung	2.611	0.008	0.134	11
	Liver	-1.516	0.079	0.923	9
	Kidney	0.031	0.034	0.769	9
	Head-Brain	-1.069	0.050	0.781	29
	SSM-Head	0.702	0.038	0.766	29
	SSM-Body	0.892	0.037	0.739	33
Stun-Bag	Heart	0	0	0	5
	Lung	2	0	0	5
	Liver	1.322	0.039	0.684	6
	Kidney	0.910	0.041	0.570	5
	Head-Brain	0.443	0.010	0.214	24
	SSM-Head	0.348	0.027	0.522	24
	SSM-Body	0.287	0.035	0.537	23
Waterball	Heart	1.212	-0.001	-0.014	10
	Lung	-0.545	0.026	0.387	10
	Liver	0.068	0.027	0.624	11
	Kidney	-0.045	-0.008	0.198	9
	Head-Brain	0	0	0	12
	SSM-Head	-0.719	0.012	0.293	12
	SSM-Body	-0.707	0.023	0.724	30
Ping Pong Ball	Heart	-2.324	0.069	0.842	12
	Lung	0.165	0.032	0.572	12
	Liver	0.650	0.037	0.574	11
	Kidney	3.295	0.019	0.833	11
	Head-Brain	-1.377	0.036	0.540	16
	SSM-Head	-1.348	0.042	0.789	16
	SSM-Body	0.936	0.028	0.559	36
Paintball	Heart	0.394	0.005	0.086	10
	Lung	0.316	0.049	0.811	10
	Liver	-0.457	0.060	0.750	7
	Kidney	-0.403	0.049	0.909	8
	Head-Brain	-0.286	0.046	0.545	16
	SSM-Head	1.804	0.032	0.490	16
	SSM-Body	3.984	0.012	0.375	27
Ricochet Round	Heart	-1.135	0.038	0.545	11
	Lung	1.307	0.041	0.663	11
	Liver	3.668	0.012	0.781	9
	Kidney	-2.706	0.075	0.808	7

TABLE III (CONT)

Projectile	Area Impacted	Intercept, b	Slope, m	Correlation Coefficient, ρ	Sample Size, N
Ricochet Round (Cont)	Head-Brain	-0.108	0.051	0.670	17
	SSM-Head	0.695	0.046	0.711	17
	SSM-Body	1.554	0.038	0.830	29
RTV Round	Heart	-1.425	0.043	0.798	9
	Lung	0.540	0.024	0.328	9
	Liver	-0.535	0.023	0.322	8
	Kidney	0.957	0.003	0.039	7
	Head-Brain	-0.721	0.020	0.525	19
	SSM-Head	0.459	0.013	0.265	19
	SSM-Body	-0.090	0.040	0.729	26

FIGURE 1. Linear Least-Squares Fit of Individual Tests with the Ping Pong Ball (Liquid-Filled) Against the Heart Area

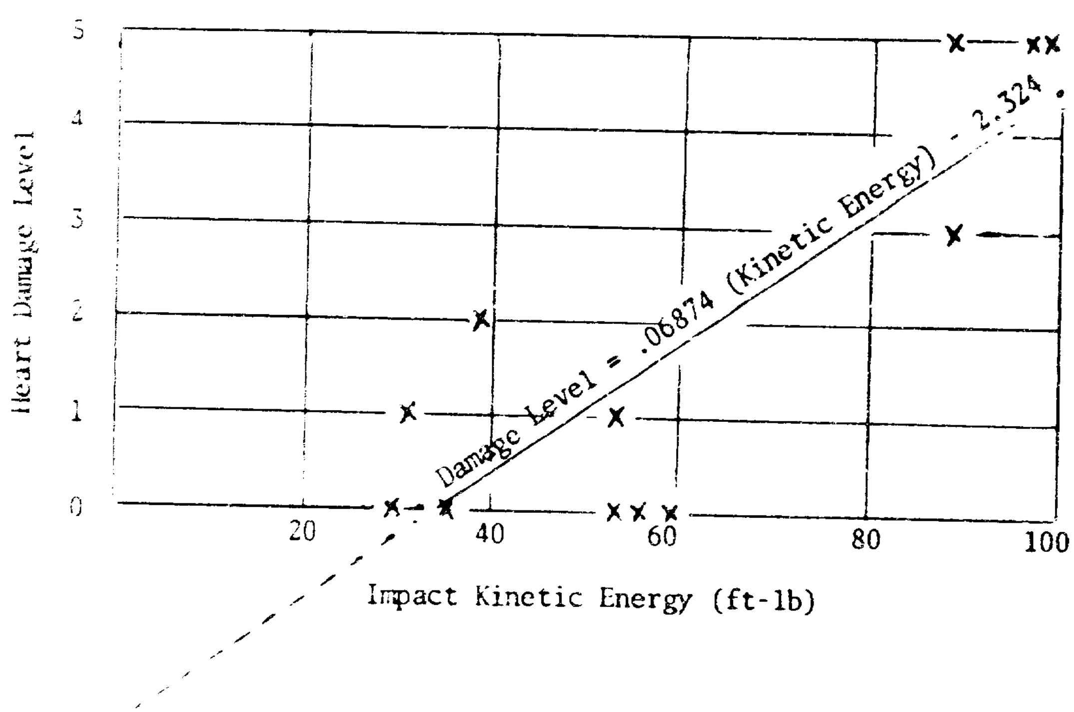
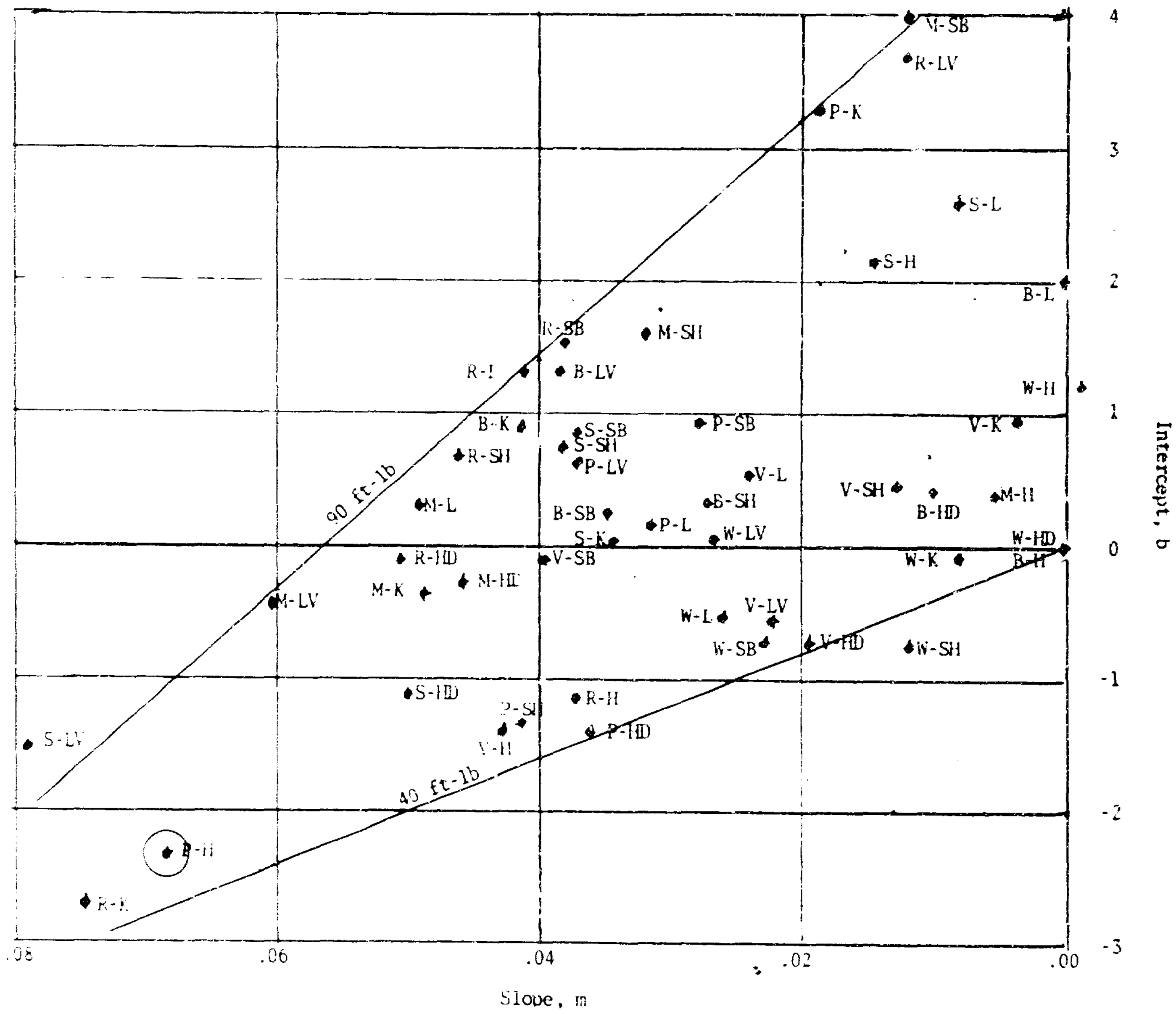


FIGURE 2. Slope/Intercept Presentation of Linear Least-Squares Fit



would represent the line going through the 40 ft-lb, Damage Level 0 point and the 90 ft-lb, Damage Level 5 point. Note again that the data of Figure 1 are represented by the single circled point in the lower left-hand corner of Figure 2.

Some appreciation of the relative danger (or morbidity) of various device organ combinations may be achieved by thinking of the top line as pivoting around an intercept value of 5 (off the top right of Figure 2). As the line sweeps down over the values and is superimposed on a point, the points are being ranked in the order of decreasing severity. Any fixed slope of this line corresponds to the kinetic energy at which a particular device-organ combination would reach Damage Level 5. A different and reverse ranking would be achieved by swinging up the bottom line while pivoted at 0,0. In the latter case, we are determining at what kinetic-energy level the slightest damage first occurs. The interesting fact is that the device-organ combinations in the lower left-hand regions of Figure 2 tend to be ranked high by both procedures. This, at first, seems like a contradiction, but it appears accurate to state that certain device-organ combinations, where the physiological response changes rapidly with kinetic energy, can be either very safe or very hazardous depending upon the kinetic energy of impact.

The set of 49 points presented in Figure 2 are reproduced in Figure 3, but this time all the organ combinations associated with the Ricochet Round and the Waterball are highlighted to show the relative damage caused by these two devices. The spatial arrangement of the two subsets of points portray in an obvious manner that the Waterball (W) is much less damaging than the Ricochet Round (R) for equivalent kinetic energy levels. Figure 4 shows the same type of presentation for the RTV Round (V) and the Paintball (M). Although the difference between these two rounds is not quite as pronounced as that of the two rounds in Figure 3, the RTV Round appears less damaging than the Paintball. It should be noted, however, that there is no real significance to the manner in which the points are connected; but, when the points tend to fall in a straight line, the linear least-squares representation of the individual combinations all tend to go through a common point for a kinetic energy vs damage level presentation, i.e., the linear representations tend toward a ray of lines.

Before discussing some observations on the general validity of the linear analysis, two additional comparisons are presented in Figures 5 and 6. These comparisons are made for specific organ areas and provide some understanding of the relative vulnerability of certain organs. In Figure 5, the projectile combinations associated with the heart and the liver are compared. It is probably significant that the lowest relative vulnerability of the liver occurs in combination with the RTV Round (V) and the Waterball (W), the two least damaging projectile types overall; otherwise, the heart area is less subject to gross tissue damage than the liver. It must be emphasized that most of these points were established on sample sizes of the order of ten and their location on the slope/intercept plane is subject to considerable error. However, a comparison of Figure 5 with Figures 3 and 4 indicates that

FIGURE 3. Comparison of Damage Caused by the Ricochet Round (R) and the Waterball (W)

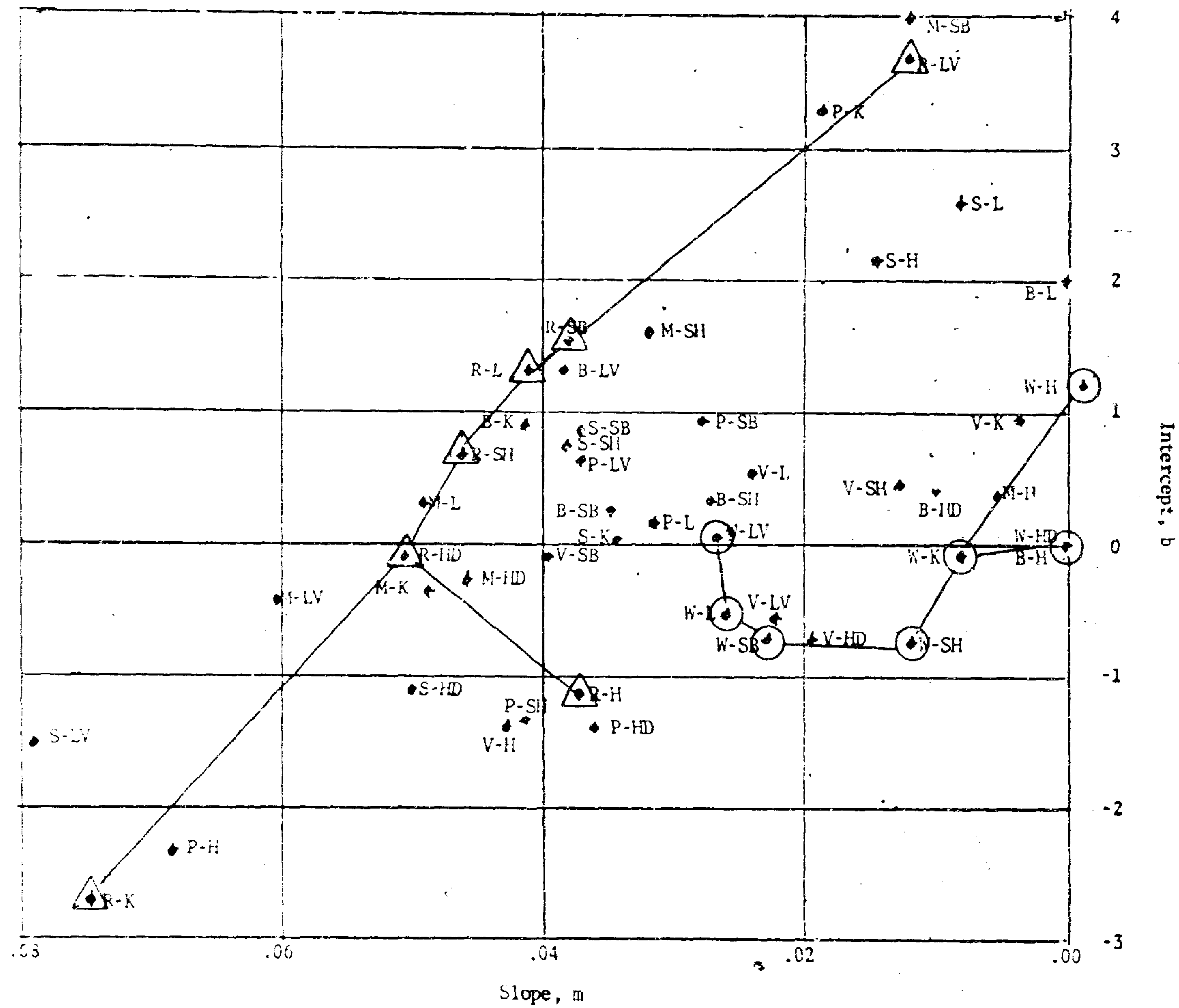


FIGURE 4. Comparison of Damage Caused by the Paintball (M) and the RTV Round (V)

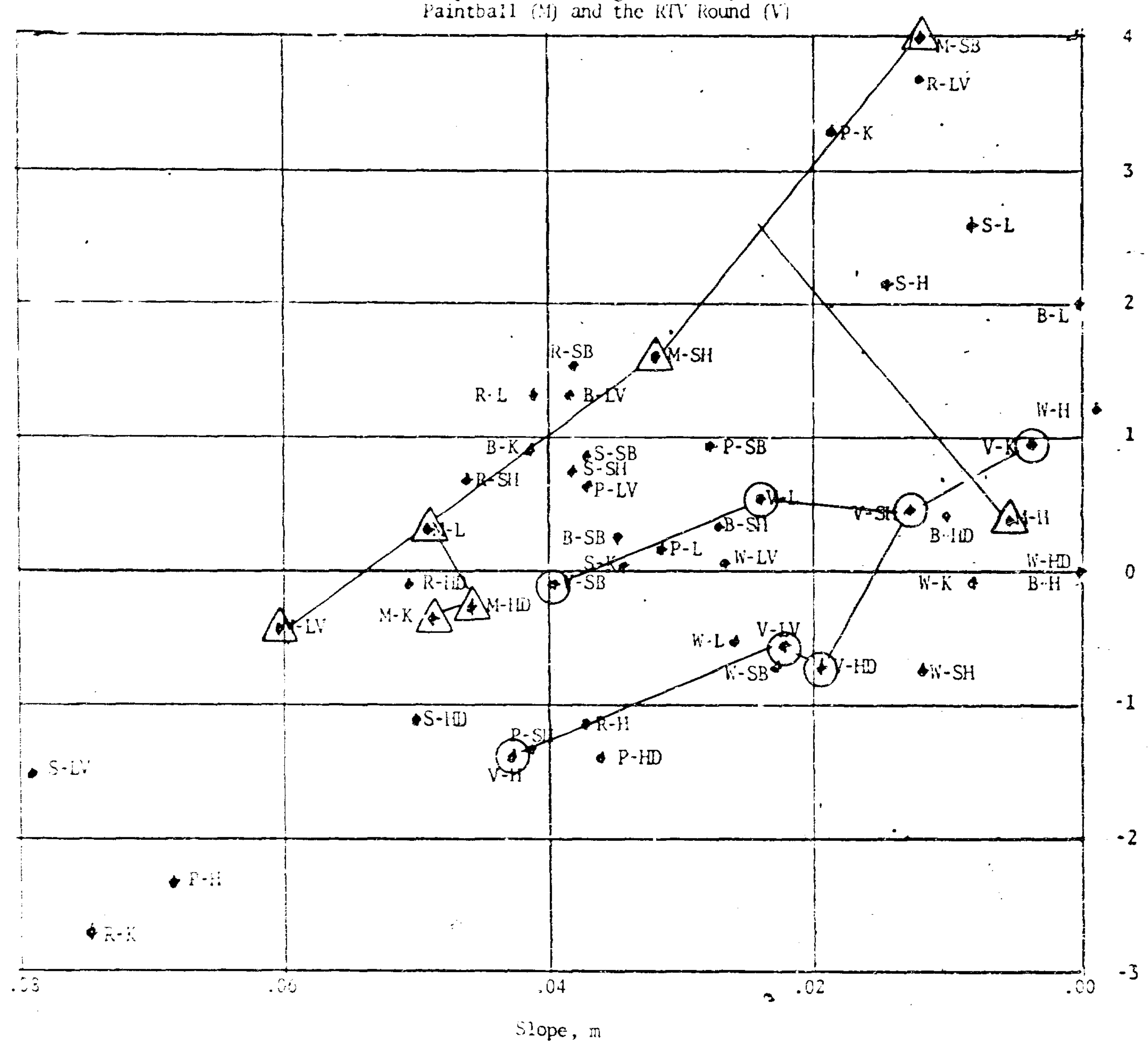


FIGURE 5. Comparison of the Relative Vulnerability of the Heart and Liver for Projectile Impacts

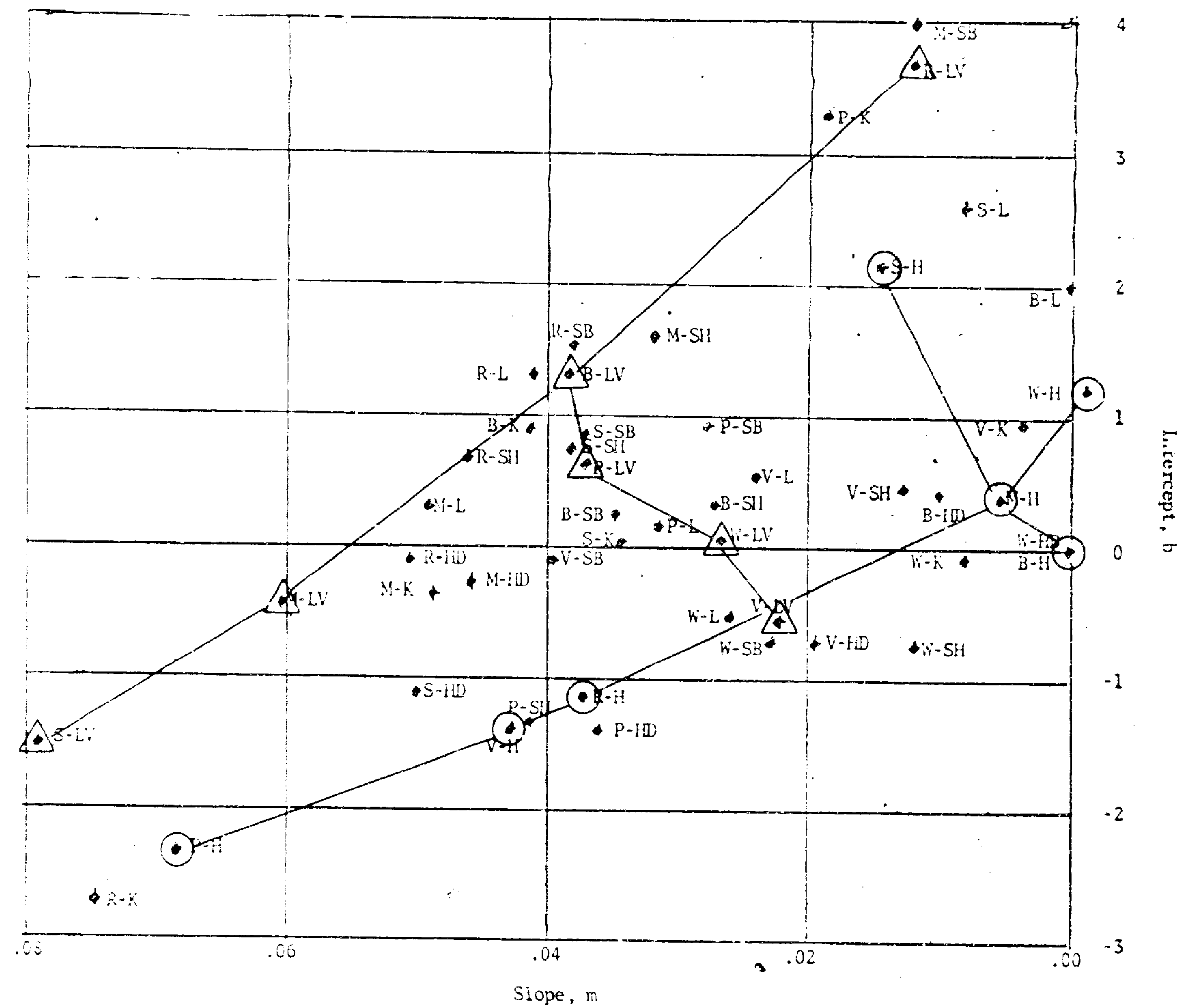
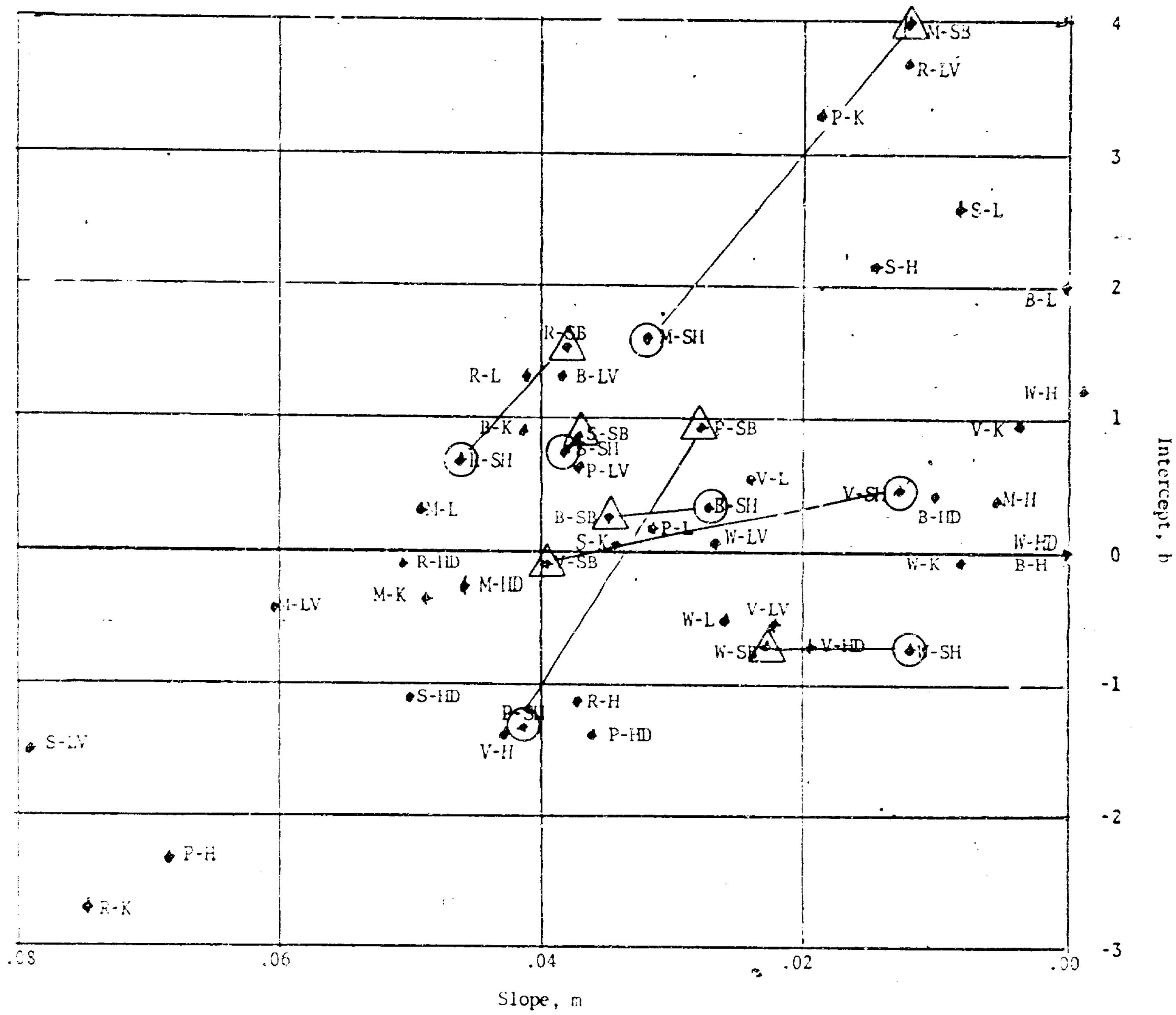


FIGURE 6. Comparison of the Relative Vulnerability of the Skin (SSM) of the Body and the Head

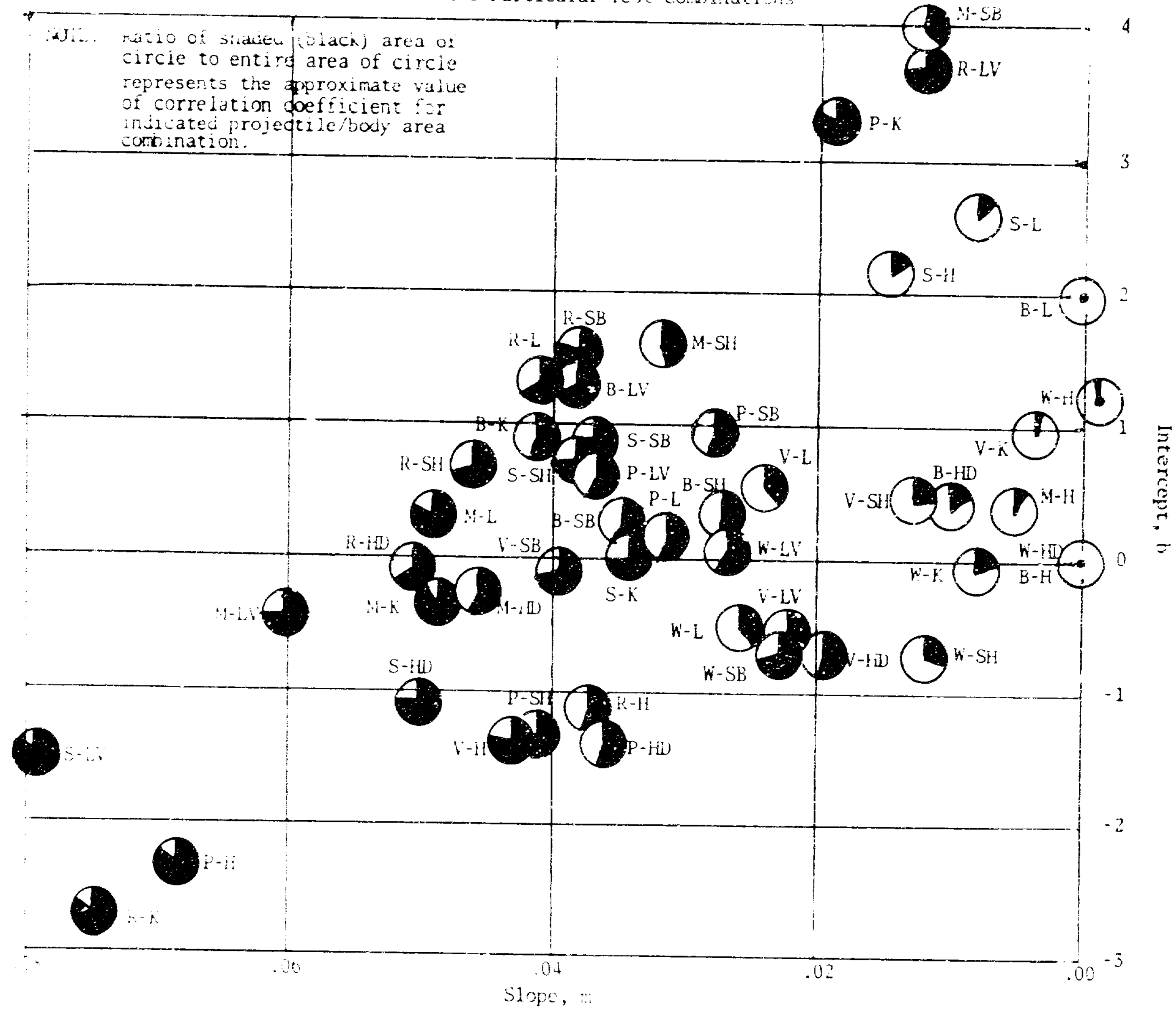


the greater difference in the physiological response measured is the result of the projectile impacting rather than the organ impacted.

Figure 6 presents an interesting comparison of the vulnerability of the two different skin (skin, subcutaneous tissue and muscle) areas, i.e., the skin of the head (SH) and the skin of the body (SB). In this instance, each of the points represents a sample size of 20 to 30 test observations, and it may be inferred that the location of the points in the slope/intercept plane are relatively well-established. The most interesting observations from Figure 6 are that the skin of the body is consistently more vulnerable than the skin of the head and that there are two totally different relations in evidence, viz., the steep slopes connecting four pairs of points and the shallow slopes connecting three pairs of points. The conclusion drawn from these observations is that the body skin is more sensitive than the head skin, both at the low-energy levels (shallow slope) and the high-energy levels (steep slope). This conclusion demonstrates primarily the value of a slope/intercept presentation rather than a significant finding on high/low-velocity projectiles, and it should be remembered that the conclusion is based on tests against baboons (head skin) and swine (body skin), i.e., two different animal species.

Although it is obvious that one of the limitations of a linear description of the data is that the physiological response may be nonlinear, there are certain other factors which should be noted. The correlation coefficients of each linear least-squares fit, given in Table III, provide some indication of the value of the linear fit. Approximate values of the correlation coefficient are displayed graphically in Figure 7, where the fraction of the circles which is black represents the approximate value of the correlation coefficient. It is felt that this representation provides a significant insight into what regions of the slope/intercept plane are most meaningful. However, some of the dramatic increase of the correlation coefficient with increasing slope must be attributed to the fact that the correlation coefficient is equal to the slope multiplied by the ratio of the standard deviations of the independent and dependent variables. On the other hand, some of the low correlations in the interval of slope from .00 to .02 must be attributed to other factors, viz., a variation in the response which is sufficiently large to preclude a good fit (S-H, S-L, B-L, V-K, M-H, W-K) or, the kinetic-energy levels selected did not correspond to the region in which physiological change occurs (W-HD, B-H, M-SB). In the latter examples, W-HD (Waterball/Head) and B-H (Stun-Bag/Heart) are excellent examples, since there were no damage levels other than "0." In the case of M-SB (Paintball/Skin-Body), there was a predominance of Grade 5 "calls" over a relatively large kinetic-energy interval, and there were very few outcomes for damage levels less than 5. Consequently, the M-SB set of data was represented by a line of small

FIGURE 7. Correlation Coefficients for the Particular Test Combinations



slope with a large intercept, whereas a more sophisticated criterion* for a linear fit would have given a steep slope (about .1) with a small intercept value. In general, the message of Figure 7 seems to be: if the predicted damage level is relatively high, the linear relation predicting this level is more believable (higher correlation coefficient), and/or if the linear relation forecasts a large change in the test interval (large slope), the relation is more believable.

Before reviewing and summarizing some of the physiological findings, another presentation of the data, which is more direct, is given in Table IV. The entries in Table IV are the predicted damage levels for an impact kinetic energy of 50 ft-lb, based on the linear least-squares fits of the data. The entries tend to confirm our previous observations based upon the slope/intercept presentation of the data which, of course, they should because they represent a special case (50 ft-lb) taken near the center of the kinetic energies tested. Rephrasing these observations, they are:

1. The Waterball and KTV Round are generally the least damaging projectiles for impacts of fixed kinetic-energy levels.

2. The heart is one of the organs least vulnerable to gross tissue damage from projectile impacts, with the exception of Superball impacts, where it was noted that the significance of the fit for this combination (S-H) was small.

3. The liver is one of the organs most vulnerable to gross tissue damage from impacts for all the devices, with the exception of the Waterball and KTV Round which are the two least damaging projectiles.

4. In every case, the skin of the head is less vulnerable than the skin of the body to gross tissue damage from projectile impacts.

It must be emphasized that these linear relations describe the damage to the immediate area impacted. The analysis which follows will provide some modifications to the above conclusions.

*It appears that a piecewise fit of the damage level/impact kinetic-energy data would be more useful. For example, if slope m and intercept b are chosen to minimize the following sum of squares, Q:

$$Q = \sum_i y_i^2 \qquad + \qquad \sum_i (y_i - mx_i - b)^2 \qquad + \qquad \sum_i (5 - y_i)^2,$$

$$\text{for} \qquad x_i < -\frac{b}{m}, \qquad -\frac{b}{m} < x_i < \frac{5-b}{m}, \qquad x_i > \frac{5-b}{m},$$

where x_i is the impact kinetic energy of a given shot and y_i is the corresponding damage level, then the predicted damage level would be "0" for $x < -\frac{b}{m}$ and 5 for $x > \frac{5-b}{m}$ and linear for $-\frac{b}{m} < x < \frac{5-b}{m}$.

TABLE IV

PREDICTED DAMAGE LEVELS AT 50 FT-LB IMPACT ENERGY

Item	Organ or Body Area						
	Heart	Lung	Liver	Kidney	Head	Skin (SSM) Head	Skin (SSM) Body
Superball	2.9	3.0	2.5	1.8	1.4	2.6	2.8
Stun-Bag	0	2.0	3.3	3.0	0.9	1.7	2.0
Waterball	1.1	1.3	1.4	0.4	0	0	0.4
Ping Pong Ball	1.1	1.8	2.5	4.2	0.4	0.7	2.3
Paintball	0.7	2.8	2.6	2.1	2.6	3.4	4.6
Ricochet Round	0.7	3.4	4.3	1.0	2.4	3.0	3.5
RTV Round	0.7	1.7	0.6	1.1	0.3	1.1	1.9

C. Probability of Undesirable Effect (P_{UE}) as a Measure of Physiological Response

It was noted in the discussion of physiological response measures that P_{UE} represents an attempt to scale the results from the test animals to a human and that P_{UE} represents the well-being of a human more accurately than damage level. Unfortunately, there is no assurance that for any given shot the organ damage which a human might sustain would be the same as that exhibited by the test animal, but test species (baboons and swine) were selected in an effort to minimize animal-to-human damage conversion problems. Later in this report, some results on correlation of damage level with animal weight will be discussed, and the qualifications on these data as applied to humans will be more evident.

The nature of the damage levels does influence the outcomes of the P_{UE}'s, since the gross tissue damage is one of the most important pieces of information used by the Medical Group in estimating P_{UE}. The extent to which a preassigned damage level grade influences the Medical Group estimates of P_{UE} is not clear; but, there is no question that the convenience of a single number, rather than a detailed medical description of the wounded area, aided the estimation of P_{UE}'s. The damage level grade was also frequently used by the analysts and support personnel to check on the consistency of P_{UE} estimates. For example, on reviewing minutes of medical meetings, if a Damage Level 3 to the skin were accompanied by a P_{UE} of .10 in one case and P_{UE} of .30 in another case, a question would be raised as why there was a difference in P_{UE} for the same grade level. The Medical Group response to this type of question invariably resulted in a detailed statement of the differences in systemic effect of the two wounds with the same damage level grade.

The analysis of the P_{UE} values for various combinations of projectiles and body areas is handled in much the same manner as the damage level analysis. One of the basic differences between the two analyses, however, is the number of body areas considered in each. The Medical Group assigned one P_{UE} value for each impact, i.e., considered the effect on the body as a whole for each body area impacted, whereas up to eight different damage level grades were assigned for a body shot and two different damage level grades for a head shot. It is emphasized that the damage level analysis did not consider damage to combination body areas like the thorax, where a thorax shot was broken down three ways as heart, lung, and skin (skin, subcutaneous tissue and muscle--SSM) damage. That is, in the damage level analysis, three separate data points were generated by a thorax shot, but only one data point is generated in the P_{UE} analysis. The skin (SSM), both body and head, is also excluded in the P_{UE} analysis as a separate body area, so the seven body areas of the damage level analysis are reduced to four body areas in the P_{UE} analysis as follows:

1. Head (brain) - HD
2. Thorax (heart and lungs) - TH
3. Liver - LV
4. Kidney - K.

The same seven projectiles of the damage level analysis are used in combination with the above four body areas in the P_{UE} analysis, and the results of linear least-squares fits to these 28 (7 x 4) combinations are given in Table V. The three right-most columns of Table V give the values of the linear fit for 30, 50 and 90 ft-lb, respectively. The same form of slope/intercept presentation as was used in Figure 7 for the 49 device-area combinations (damage level vs kinetic energy) is also used for the 28 device-area combinations (P_{UE} vs kinetic energy) in Figure 8 below. As in Figure 7, the correlation coefficient of the P_{UE} vs kinetic energy relation is indicated by shading the circle to represent the specific relation. Also, as before, the percent of shading represents the approximate value of the correlation coefficient.

There are several fundamental changes to previous conclusions, based only on gross tissue damage to the impacted area, which should be made now based upon the P_{UE}'s thus derived. First, the larger projectiles (especially the Stun-Bag) appear to be more hazardous relative to the smaller projectiles on the basis of P_{UE} estimates, but the larger projectiles are still generally less hazardous for given kinetic-energy levels than the smaller projectiles. The Stun-Bag's relatively poorer showing is undoubtedly due in part to a number of cases in Stun-Bag shots where there were areas of necrosis in the liver without fracture of the liver. The medical judgment was that such necrosis would result in a sick patient for at least several days, thus giving a high P_{UE} for a relatively low damage level. Generally, it appears that the larger projectiles are causing damage in a large body area (e.g., the thorax) even though the damage at the point of impact (heart, lung, skin) is not extremely large. This phenomenon causes the P_{UE}'s for such large body areas to be relatively higher when compared to P_{UE}'s for smaller body areas. To repeat, the smaller projectiles position did not necessarily improve relative to all the projectiles, and there is some indication that the Paintball (M), the smallest projectile, exhibits some of the less-attractive characteristics of the larger projectiles in that there seemed to be a tendency for multiple areas to be damaged from a single shot of the Paintball. There is no direct evidence assembled, but it is conceivable that the multiply-damaged areas result from the "penetration type" wound of the Paintball.

The previous conclusion (based on damage level analysis only) on the relative invulnerability of the heart to gross tissue damage must be generally discounted when the results of the P_{UE} analysis are taken into account. It appears from Figure 8 that the thorax area as a whole is about as vulnerable

TABLE V

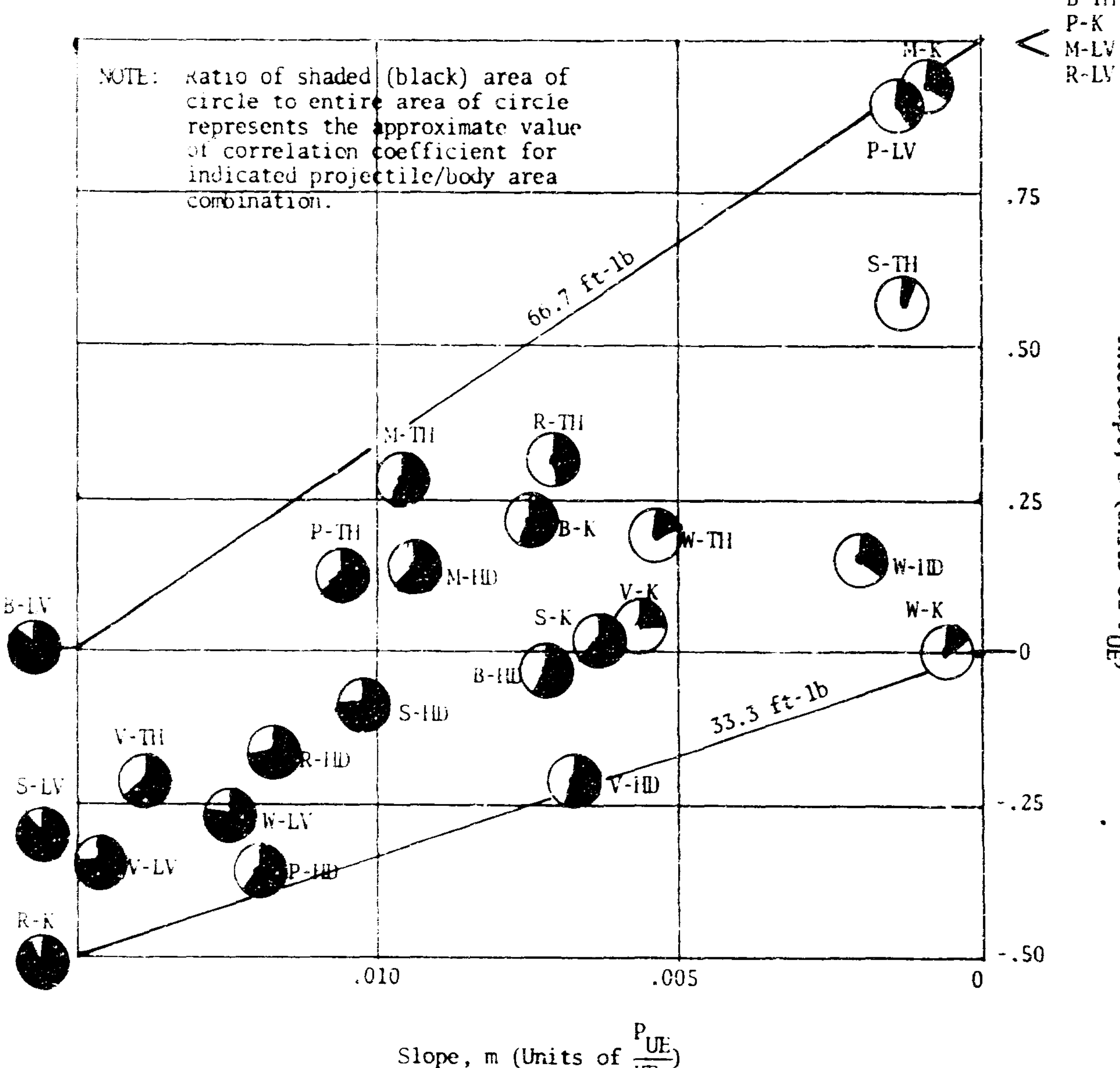
PROBABILITY OF UNDESIRABLE EFFECT, P_{UE}, VS KINETIC ENERGY

Projectile	Area Impacted	Intercept, b	Slope, m	Correlation Coefficient, ρ	Sample Size, N	P_{UE} at Indicated Energy Level 30 ft-lb	50 ft-lb	90 ft-lb
Superball	Head	-0.190	0.0102	0.747	25	0.12	0.32	0.73
	Thorax	0.576	0.0012	0.076	12	0.61	0.64	0.69
	Liver	-0.300	0.0156	0.913	9	0.17	0.48	1
	Kidney	0.009	0.0064	0.640	9	0.20	0.33	0.58
Stun-Bag	Head	-0.026	0.0071	0.551	24	0.19	0.33	0.62
	Thorax	1	0	0	6	1	1	1
	Liver	-0.003	0.0158	0.875	6	0.47	0.79	1
	Kidney	0.217	0.0075	0.560	5	0.44	0.59	0.89
Waterball	Head	0.153	0.0020	0.335	14	0.21	0.25	0.33
	Thorax	0.185	0.0054	0.211	11	0.35	0.46	0.67
	Liver	-0.270	0.0124	0.711	11	0.10	0.35	0.85
	Kidney	0	0.0005	0.158	8	0.02	0.03	0.05
Ping Pong Ball	Head	-0.365	0.0120	0.589	16	0	0.24	0.72
	Thorax	0.127	0.0106	0.662	12	0.45	0.66	1
	Liver	0.898	0.0013	0.388	11	0.94	0.96	1
	Kidney	1	0	0	11	1	1	1
Paintball	Head	0.134	0.0096	0.640	17	0.42	0.61	1
	Thorax	0.278	0.0096	0.569	11	0.57	0.76	1
	Liver	1	0	0	7	1	1	1
	Kidney	0.922	0.0008	0.307	8	0.95	0.96	1
Ricochet Round	Head	-0.168	0.0118	0.722	18	0.19	0.42	0.89
	Thorax	0.315	0.0071	0.472	12	0.53	0.67	0.96
	Liver	1	0	0	9	1	1	1
	Kidney	-0.517	0.0156	0.950	7	0	0.27	0.89

TABLE V (CONT)

Projectile	Area Impacted	Intercept, b	Slope, m	Correlation Coefficient, ρ	Sample Size, N	P_{UE} at Indicated Energy Level: 30 ft-lb	50 ft-lb	90 ft-lb
RTV Round	Head	-0.214	0.0063	0.546	20	0	0.12	0.40
	Thorax	-0.216	0.0139	0.644	9	0.20	0.48	1
	Liver	-0.350	0.0147	0.762	8	0.09	0.38	0.97
	Kidney	0.040	0.0156	0.262	7	0.21	0.32	0.54

FIGURE 8. Correlation Coefficients for Various Projectile/Body Area Test Combinations



to undesirable effects as the liver area in this analysis. This does not mean that the heart is not a tough organ physically (the results from the damage level analysis verify this statement), but it does mean that the toughness of the heart organ is not a critical factor in the overall morbidity of thorax impacts. For example, the P_{UE} value for thorax impacts includes gross damage to the heart and the lung. The thorax P_{UE} value also reflects contributions from EKG abnormalities as well as the specific nature of the gross tissue damage and its anticipated systemic effect.

The comparable vulnerability to undesirable effects of the thorax and liver area impacts is really more surprising than the above discussion would indicate. An examination of the damage levels of Appendix B indicates that the small missiles impacting against the liver area cause damage to the heart and lung (as will large missiles) and also introduce EKG disturbances, so that one might expect that the compounding effect of P_{UE} values would make the liver that much more vulnerable and, in fact, it does. For the P, M, and R projectiles (Ping Pong Ball, Paintball, and Ricochet Round, respectively), the liver area impacts are more dangerous as measured by P_{UE} than the thorax area impacts. For the remaining projectiles, the thorax area is more vulnerable (in some cases, for example, the RTV Round, only slightly more vulnerable) than the liver area, but it will also be noted for these projectiles that thorax area shots will tend to produce liver damage, which is not the case with the P, M and R projectiles.

Before making conclusions on the overall "nonlethal" weapons implications of these findings, it should be noted that the P_{UE} results tend to be more revealing than the damage level results, i.e., where damage level for the area impacted only is examined! There are only two results, S-TH and W-K, which appear in a bad region of the slope/intercept plane with a small correlation coefficient, and even W-K could be a reasonable description of the Waterball-Kidney interaction since there were only three non-zero grades assigned for the damage level other than the skin. Two of these were kidney damage grades with values 1 and 3, respectively, and there was a damage level 1 for "other viscera." It should also be noted that the W-K value is located in about the same relative position for both the P_{UE} and the damage level vs kinetic energy analyses. Furthermore, the correlation coefficient between damage level and P_{UE} is .95 which means that P_{UE}, in this case, is based primarily on the gross tissue damage to the kidney. There is also some understanding of the S-TH value and it will be described below. It too appears in the same relative region as the S-L and S-H values for the damage level vs kinetic energy analysis.

The pertinent question now is what has been learned about the effects of these seven different projectiles? First, the RTV Round, which is the most flexible, elastic projectile of the seven, and the Waterball, which is the largest frangible projectile, are the least damaging projectiles for fixed kinetic energy levels. These conclusions are independent of which analysis, P_{UE} vs kinetic

energy or damage level vs kinetic energy, is examined. It is fairly evident that the high-energy sphere (Superball) looks relatively less dangerous in the P_{UE} analysis than in the damage level analysis, and a similar conclusion may be inferred for the Ricochet Round. On the other hand, the Paintball and the Ping Pong Ball look relatively more dangerous in the P_{UE} analysis. If we rank the various devices by a simple averaging of the predicted physiological responses for "critical" body areas, we have the following:

Projectile	Average Damage Level		Average P_{UE}	
	30 ft-lb	50 ft-lb	30 ft-lb	50 ft-lb
Waterball	0.50	0.74	0.17	0.27
RTV Round	0.50	0.88	0.12	0.32
Paintball	1.20	2.04	0.74	0.83
Ping Pong Ball	1.36	2.00	0.60	0.72
Stun-Bag	1.48	1.84	0.52	0.68
Superball	1.58	2.32	0.28	0.44
Ricochet Round	1.58	2.36	0.43	0.59

It should be noted that the three liquid-filled projectiles, viz., Paintball, Ping Pong Ball and Waterball, were test expedients and the physical characteristics of the shells containing th liquid were not chosen to provide a specified rupture condition. It can be stated that all projectiles did rupture during the tests which were run for record. There were some initial failures to rupture for the Ping Pong Ball, but this was resolved by scoring the surface to provide fracture lines. The point is that no definite conclusions or relation can be established on the critical diameters of liquid-filled projectiles, but it does appear that somewhere between the 1-3/8" Ping Pong Ball and the 3" Waterball there is a considerable reduction in damage for constant energy of impact. Furthermore, another factor of ten reduction in the weight from the Ping Pong Ball to the Paintball did not result in an appreciable overall change in physiological effect.

Another observation is that the smaller projectile tends to produce more localized damage, but for the smallest projectile (Paintball), this could mean localized to a wound tract; hence, for relatively high kinetic energy and deep penetration of small missiles, multiple areas may be affected. It would appear that there is some intermediate "optimum" size of missile which will give primarily local damage. Finally, the very obvious conclusion about projectile characteristics is that a soft elastic consistency is the best of any of the concepts considered in this evaluation.

Before proceeding to certain system considerations, some comment should be made about the level of P_{UE} values which represent various projectile/body area responses. The first reaction, if some analogy is made to more familiar situations, is that the values are too high to represent human responses. For example, a baseball lobbed from base to base should give about a 30 ft-lb impact, whereas a fast pitched ball is on the order of 100 ft-lb. Assuming that most of the energy from a baseball impact would be absorbed, the closest projectile to the baseball in this investigation would be the Stun-Bag. The linear prediction for P_{UE} of the Stun-Bag at 30 ft-lb is .52. Intuitively, this seems high. However, the 100 ft-lb impact of a Stun-Bag gives an average estimate of .91 for P_{UE}. If a relaxed person is hit by a fast pitched ball on the head, thorax, liver or kidney area, it does not violate intuition to state that chances are very good that the individual will not be able to perform routine daily tasks the following day.

Irrespective of the validity of the above "popular appeal" type of argument, some calculations were performed to investigate whether or not the test animal sizes were a contributing factor in the physiological response estimates. First, a set of linear regressions for damage level vs body weight was determined for the five projectile series where animal weights were in the data base. The slopes of these linear least-squares fits were generally negative (sufficient evidence to indicate that body weights were a factor). Next, a second statistical investigation was made, using a multiple linear regression where both kinetic energy and body weight were used to predict first damage level, then P_{UE}. The slopes (coefficients of regression) were both positive and numerically "close" to the single linear regression values for the kinetic energy coefficients, and the slopes for the body weight variables were negative as before. The ratio of the coefficient to the standard deviation of the coefficient was calculated for both the kinetic energy and body weight variables. These ratios indicate the significance of the fit for each of the variables and, in general, the ratios for the kinetic energy variables were greater than those for the body weight variables. However, both ratios were frequently highly significant. The conclusion is that both body weight and kinetic energy are major contributions to the physiological response as measured both by damage level and P_{UE}. Furthermore, kinetic energy is the more dominant variable. Since the animal weights were frequently within the range of 20 to 30 pounds, it could be inferred that the physiological response observed is greater than would be expected from a larger animal of grown human proportions. A less certain conclusion is that full-grown humans would not have received as much damage for given kinetic-energy levels as that observed in the test animals. A great deal of care must be exercised in extrapolating results outside the test weight interval. For example, the inverse body weight correlation with damage could very logically mean that for animals of the same maturity, the lighter animal is more susceptible to damage.

The decision to test small pigs was based upon a judgment that the skin, subcutaneous tissue and muscle layer would resemble that of a human more nearly than that of a larger animal of equivalent adult human weight. Furthermore,

it was assumed that the skin would provide a more sensitive response than the critical soft organs. In general, this assumption holds for damage level response as exhibited by the consistent positive intercepts (of Figure 2) for the different skin/projectile relations.

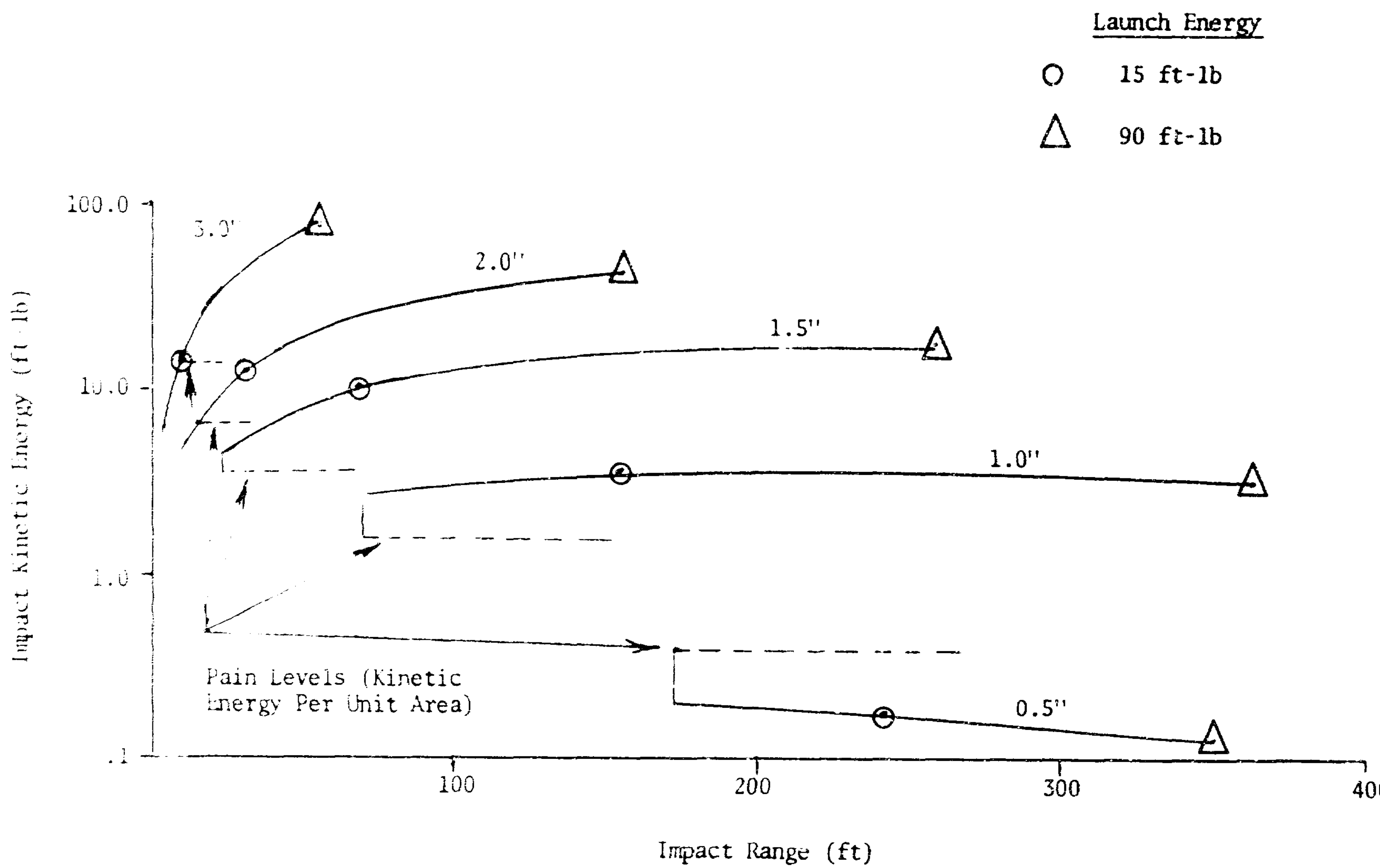
D. Other System Considerations Influencing Less Lethal Weapon Characteristics

All the previous discussions were oriented toward understanding physiological response as a function of impact (or preimpact) conditions. At this point, some discussion is warranted on an approach to establishing the characteristics of less lethal projectiles where these projectiles follow ballistic trajectories from launch. Since a projectile must act at a distance in order to provide some effect on target and safety to firer, there are two dominant conditions, viz., gravity and air drag, which will influence the choice of a projectile size. In the following discussion, only spherical projectiles of the density of water (1 gm/cc) will be considered.

Figure 9 is a plot of the impact kinetic energy vs range for "water" projectiles of various diameters. The launch angle is 5° in all cases. An inspection of Figure 9 indicates that the heavier (larger diameter) projectiles are extremely range-limited for kinetic energies of launch which are reasonably safe (low kinetic energy)! Essentially, what is pictured in this figure is the trade-offs for launch impacts vs stand-off (downrange) impacts; i.e., if an attempt is made to provide a projectile which would cause little damage at the muzzle (if someone were inadvertently hit at the muzzle) yet the projectile must have some "effect" downrange, then there is a tremendous difference between a 1/2" projectile and a 3" projectile. It should be emphasized that the trajectory information in Figure 9 is based upon a 5° launch (super elevation) angle. Depending upon the sight utilized for a launcher, this could be an appreciable source of error in hitting a target. For example, at 200 feet range a 5° launch angle would require the firer to aim about 15 feet above the intended impact point on the target.

Before discussing the additional information on Figure 9, it should be noted that a very specific and restrictive set of objectives was stated above for impacting less lethal projectiles, viz., low chance of injury at the muzzle, combined with a capability to produce an "effect" downrange. Unfortunately, the scope of this report must be limited and the various discussions on "effect" in Reference 1 can be stated only briefly. However, it is fairly evident that the only effect that nonhazardous kinetic energy projectiles can be expected to achieve is pain or threat of pain. If "nonlethal" devices are characterized crudely as either incapacitating or dispersing, then it must be concluded that individual impacting projectiles can only disperse if there is a requirement that the projectiles produce little, if any, injury on impact. Furthermore, there is no certainty that painful impacts will induce a crowd to disperse. However, the utilization of chemical irritants (tear gas) in crowd control has in many cases evoked the desired control force objectives, i.e., crowd dispersal, and it is probable that much of the desired effect was achieved when crowd members avoided the discomfort of respiratory distress, tears and painful irritation rather than when crowd members were physically experiencing the specific physiological responses of exposure to

FIGURE 9. Water-Filled Sphere Impact Kinetic Energy vs Range to Impact (5° Launch Angle)



large doses of chemical irritants. Both the analysis of crowd behavior under actual confrontation conditions and the calculation of required dosages of chemical irritants for open areas tend to confirm that a crowd disperses to avoid the threat of discomfort rather than as a direct result of chemical irritant doses which are highly discomforting. The above comments are injected as a caution in the event the results of this report are interpreted in the sense that all that can be expected from kinetic energy "nonlethal" projectiles is pain. It is conceivable that threat of pain is sufficient to obtain the desired effect. Additionally, one of the reasons for considering kinetic-energy projectiles is that under many wind conditions and tactical situations, chemical irritants are unreliable.

Returning to Figure 9, constant kinetic energy pain levels for the various diameter projectiles are indicated by dashed lines for the corresponding kinetic energy vs range relations. The kinetic energy pain levels are based upon experiments (recorded in Reference 1) where a very simple set of tests were run with human subjects to establish impact pain threshold levels for several different diameter projectiles. The values indicated for pain level on Figure 9 are based upon an energy per unit area which is ten times the estimated pain threshold. The limitations of the "ten times threshold" pain criterion are appreciated; however, this criterion is the most reasonable information available which provides a quantitative measure of desirable effect at low impact energy levels.

It seems fairly clear that there are two opposing factors affecting range/velocity which will influence the selection of a specific diameter for a water-filled sphere, viz., gravity tends to limit the range of larger projectiles and air drag makes the smallest projectiles ineffective through rapid velocity slow-down. The specific maximum "effective" ranges which may be achieved for a given projectile depend upon the physiological response information developed in this report as well as the selection of an "optimum" launch angle and required range for that angle. The optimization process is not complete. Additional tests should be run against animals to obtain more reliable information in the .75-1.5" diameter region. It is very reasonable that these tests should be restricted to projectiles constructed from a soft elastic material. In addition, more precise trajectories should be calculated based upon actual characteristics of rounds. Anotl r optimization factor, viz., time of flight, should be considered since short times of flight tend to increase accuracy of shooting.

However, it does appear reasonable to conclude at this point in time that the RTV Round tested has a distinct superiority over the other configurations tested and should provide very few injuries on impact if fired below 30 ft-lb launch energy. An RTV Round fired at 30 ft-lb muzzle energy and a 5° launch angle should be safe at the muzzle and provide a painful impact at 200 feet range.

E. Tests with the Water Cannon and Other Mechanisms of Desirable Effect

In addition to the projectile firings discussed previously, LWL conducted twenty firings against swine using a water dispensing system (see Reference 7). The parameters of impact are, of course, completely different from those associated with the seven projectiles. Nominally, the conditions for the physiological tests were a 2.9-gallon pulse of water at 300 psi from a 3/4" nozzle. The velocity of the water at various ranges from the muzzle was calculated measuring observed shifts in the water rod in the high-speed photographs. The pre-impact energy of the water rod was calculated to be between 5,000-10,000 foot pounds, depending upon the range and variations occurring in the actual test firings. The results of these tests are not given in the data base of Appendix B, but significant parameters and test results are given in Table VI below. It is evident from the P_{UE} values that there is no appreciable correlation of damage with range and, in addition, the average overall P_{UE} of .27 indicates a relatively low hazard considering the amount of energy available prior to impact. Unfortunately, the closing of the Land Warfare Laboratory (LWL) did not permit an extensive reduction and analysis of all the Fastax film data, but there is a completely different mechanism involved in the water rod impacts when compared to small projectile impacts. First, a considerable amount of energy in the water impact of the water cannon is utilized in accelerating the whole test fixture (including the animal), i.e., much of the energy is involved in momentum transfer. In addition, the pulse duration is sufficiently long such that the water after some time is impinging on a moving object and at the end of the pulse is either missing the target altogether or striking at a very low obliquity. The actual times associated with the various events may be estimated from the Fastax film but this measurement task was not accomplished.

The gross difference in the nature of the tests (water cannon vs projectile) was sufficient to indicate that massive amounts of energy may be available pre-impact without inducing a corresponding massive tissue disruption to the test animal at impact. The significant difference between the massive energy of the water rod in the water cannon tests and the other tests with projectiles is that some specific desirable effect on the targeted individual may be achieved in addition to the introduction of pain; namely, the moving individual may be stopped or knocked down with a water rod, since there is sufficient force available to decelerate or overturn an individual.

It is unfortunate that sufficient time was not available to provide an adequate discussion and analysis of the desirable effects aspects of less lethal weapons, since considerable information was developed in the course of the LWL programs on desirable effects estimates. However, the quality of the information was such that is was judged to be of smaller value than the physiological effects information discussed at length in this report; hence, it was, for the most part, excluded.

In addition to the unreported desired effects information for kinetic-energy projectiles, LWL has been involved with evaluating the desirable and undesirable effects of chemical and electrical devices. For example, tests using Rhesus monkeys and the TASER (an electrical device) have been conducted in an effort to grossly quantify electrically incapacitating effects.

TABLE VI

RESULTS FROM WATER DISPENSER TESTS

Range to Impact (ft)	Orientation	Shot No.	Pulse Duration (sec)	Velocity	P_{UE}
6.5	Front	906	.722	193.5	0
	Front	907	---	---	.25
	Front	914	.725	151.3	0
	Front	915	.753	167.8	0
	Front	916	.735	150.9	.25
17.0	Front	900	.752	160.8	0
	Front	901	.602	159.1	0
	Front	902	---	---	1.0
	Back	903	.700	157.2	.5
	Back	904	.665	148.8	0
	Back	905	---	---	.25
37.5	Front	908	---	123.7	0
	Front	909	.571	134.0	0
	Front	910	.523	147.0	0
	Back	911	.656	133.0	.5
	Back	912	.555	130.0	.5
	Back	913	.552	120.0	0
45.0	Front	917	.484	141.7	.10
	Front	918	.482	149.5	1.0
	Front	919	.455	142.0	1.0

III. OBSERVATIONS AND COMMENTS

There is now considerable information to support what can and what cannot be done with impacting projectiles in the area of less lethal weapons. First, there is much evidence that a device/projectile can be made which will be muzzle-safe (cause no appreciable damage from impacts at the muzzle of a launcher) and which will provide desired effects at ranges of interest. Furthermore, there are some data and analyses to help identify "optimum" characteristics of such a projectile, if the projectile is spherical.

The LWL investigation has not extensively addressed less lethal mechanisms for stopping and/or immobilizing individual people; however, the evidence available suggests that hazards must be accepted if a device is to be used to "reliably" stop or immobilize an individual in open areas. This statement includes consideration of electrical, chemical and mechanical devices.

In summary, a great deal of basic data from animal impact tests conducted over a period of two years is presented in Appendix B. The corresponding physiological responses to projectile impacts are summarized by linear least-squares fits to the numerous projectile/body area combinations and are presented in Tables III and V of the report. Irrespective of the value of the analysis and conclusions given in the report, this basic information should be of considerable value to any group interested in blunt-trauma injury.

IV. APPENDICES

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APPENDIX A

DAMAGE LEVEL CRITERIA

Criteria for the Evaluation of Damage Resulting From Blunt Trauma

I. Skin, Subcutaneous Tissue and Muscle

(Grade)	Criteria
1	Superficial blemish or signature in skin
2	Grade 1 plus subcutaneous hemorrhage and/or edema
3	Grades 1 and/or 2 plus subcutaneous and/or intramuscular hematoma
4	Grades 1, 2 and/or 3 plus laceration of fascia
5	Grades 1, 2, 3 and/or 4 plus laceration of skin

II. Kidney

1	Superficial contusion with subcapsular hemorrhage and/or perirenal hemorrhage
2	Grade 1 plus superficial laceration of cortex not penetrating more than 2-3 mm
3	Grade 1 plus simple laceration of kidney penetrating to pelvis
4	Grades 1, 2 and/or 3 plus multiple lacerations
5	Grades 1, 2, 3 and/or 4 plus rupture of capsule and destruction of kidney

III. Liver

1	Subcapsular hematoma with no visible fracture of liver
2	Grade 1 plus simple fracture of liver less than 1 cm deep and/or less than 5 cm long
3	Grades 1 and/or 2 plus rupture of capsule and fracture of liver 1-2 cm deep and/or less than 10 cm long

III. Liver (Cont)

(Grade)	Criteria
4	Grades 1, 2 and/or 3 plus fracture greater than 2 cm deep and/or greater than 10 cm long
5	Fragmentation of liver

IV. Spleen

1	Subcapsular hematoma less than 5 cm in diameter
2	Subcapsular hematoma greater than 5 cm in diameter and/or minor intrasplenic hemorrhage
3	Grades 1 and/or 2 plus rupture of capsule less than 1 cm long
4	Grades 1 and/or 2 plus capsular rupture greater than 1 cm long
5	Disruption of spleen, laceration of substance of spleen--torn capsule

V. Lung

1	Small contusion of lung with subpleural hemorrhage less than 5 cm in diameter and extending less than 1 cm into lung
2	Subpleural hemorrhage greater than 5 cm in diameter and/or multiple hemorrhages less than 5 cm in diameter
3	Grades 1 or 2 with pleural rupture and pneumothorax
4	Grade 3 with bilateral pneumothorax
5	Deep tears in lung parenchyma with hemopneumothorax

VI. Other Viscera

1	Less than 1 cm subserosal hemorrhage
2	Greater than 1 cm subserosal hemorrhage
3	Grade 2 plus serosal laceration and/or mesenteric lacerations

VI. Other Viscera (Cont)

(Grade)	Criteria
4	Single rupture of viscera and/or diaphragm
5	Multiple rupture of one or more viscera

VII. Bone

1	Periosteal hemorrhage without visible fracture
2	Simple fracture with no displacement
3	Fracture with lateral displacement without perforation of pleura (rib)
4	Fracture with lateral displacement plus perforation of pleura (rib) or multiple simple fractures or compound fracture of long bone
5	Fragmentation of bone

VIII. Head

1	Linear fracture of skull and/or minor epidural or subdural hemorrhage and/or contusion of brain less than 2 mm in diameter
2	Grade 1 plus subcritical intracranial hemorrhage*
3	Depressed fractures of skull with subcritical intracranial hemorrhage and/or limited brain contusion
4	Critical intracranial hemorrhage and/or multiple linear or depressed fractures of skull
5	Massive intracranial hemorrhage with extensive laceration and contusion of brain--immediate death or death prior to sacrifice

*Critical intracranial hemorrhage is defined as that volume of accumulated blood required to produce coma due to increased intracranial pressure.

IX. Heart

1	Epicardial and/or myocardial hemorrhages 2 cm or less in diameter
2	Epicardial and/or myocardial hemorrhages greater than 2 cm in diameter

IX. Heart (Cont)

(Grade)	Criteria
3	Grade 2 plus myocardial necrosis less than 2 cm in diameter
4	Grade 2 plus myocardial necrosis greater than 2 cm in diameter
5	Rupture of heart

APPENDIX B

DATA BASE

All the basic data from the seven less lethal projectiles discussed in the report have been placed in a data base for computer retrieval and analysis. The complete data base is on a Digital Equipment Corporation PDP-11/10 computer. With the close-out of LWL, the less lethal investigations, along with cognizant personnel and computer (plus data base), have been transferred to the US Army Human Engineering Laboratory (HEL) at Aberdeen Proving Ground, MD.

This appendix contains selected printouts of 16 of a possible 40 different quantifications on each test shot. Table B-I gives a description of each of the currently possible quantifications; hence, the definitions and explanations of the entries of Tables B-II through B-IX may be obtained by checking the table column headings against the descriptions given in Table B-I.

It is the intention of the investigators to continually update the information in the data base, at least to the extent permitted by supporting funds.

TABLE B-I

DATA BASE DESCRIPTIVE INFORMATION

Field	Spaces Occupied	Field Content	Remarks**
1	4	Record Number*	
2	4	Shot Number	
3	6	Date of Shot	Month, day & year; e.g., ØGØ774 to represent June 7, 1974
4	4	Time of Shot	Hour & minute; e.g., Ø852 to represent 8:52 a.m.
5	2	Test Item*	Ø1 = Superball I, Ø2 = Superball II, Ø3 = Superball III, Ø4 = Stun-Bag, Ø5 = Waterball, Ø6 = Ping Pong Ball, Ø7 = Paintball, Ø8 = Ricochet Round, Ø9 = RTV Round
6	6	Projectile Velocity*	Feet per second
7	5	Projectile Weight*	Grams
8	6	Projectile Area	Sq cm, represents presented area
9	3	Animal Number	
10	2	Species of Test Subject*	Ø1 = baboon, Ø2 = swine
11	6	Animal Weight*	Kilograms
12	3	Animal Dimensions	Inches
13	2	Target Area, Nominal	Ø1 = temple, Ø2 = anterior head, Ø3 = posterior head, Ø4 = nasal/oral, Ø5 = heart, Ø6 = lung, Ø7 = thorax (heart & lung), Ø8 = liver, Ø9 = kidney, 1Ø = thigh, 11 = spleen
14	2	Target Area, Hit*	Same as above.

*Field content item printed-out in subsequent tables of this appendix.
**In those cases where information is not presently available, -1 has been used as a temporary indicator.

TABLE B-I (CONT)

Field	Spaces Occupied	Field Content	Remarks**
15	5	Time on Target	Milliseconds; -Ø2ØØ = imbedded
16	2	Hit Qualifier	ØØ = OK, Ø1 = glancing blow, Ø2 = missed target organ, Ø3 = glancing impact & missed target organ
17	2	Heart Grade*	PD (physical damage, as opposed to EKG changes)
18	2	Head Grade*	Includes both skull and brain damage
19	2	Lung Grade*	
20	2	Kidney Grade*	
21	2	Spleen Grade	
22	2	Liver Grade*	
23	2	SSM Grade*	Skin, subcutaneous tissue & muscle
24	2	Other Viscera Grade*	
25	2	Other Grade	
26	2	Bone Grade	
27	2	Bone Number	Code for identifying bone affected
28	2	EKG-1 Grade	CD (conduction disturbance)
29	2	EKG-2 Grade	MI (myocardial infarction)
30	4	P_{UE}*	Probability of undesirable effect (all scenarios)
31	4	P_{DE} SA-1	Probability of desirable effect, Army Scenario I

*Field content item printed-out in subsequent tables of this appendix.
**In those cases where information is not presently available, -1 has been used as a temporary indicator.

TABLE B-I (CONT)

Field	Spaces Occupied	Field Content	Remarks**
32	4	P_{DE} SA-2	Probability of desirable effect, Army Scenario II
33	4	P_{DE} SA-3	Probability of desirable effect, Army Scenario III
34	4	P_{DE} SC-1	Probability of desirable effect, Civil Scenario I, LEAA
35	4	P_{DE} SC-2	Probability of desirable effect, Civil Scenario II, LEAA
36	4	P_{DE} SC-3	Probability of desirable effect, Civil Scenario III, LEAA
37	4	P_{DE} SC-4	Probability of desirable effect, Civil Scenario IV, LEAA
38	4	Time of Death	Minutes, measured from time of shot to time animal dies or is sacrificed
39	2	Death Qualifier*	Ø1 = test induced, Ø2 = sacrificed, Ø3 = suspicion of overdose of anesthesia, Ø4 = animal died overnight, Ø5 = unexplained
40	2	Shot Qualifier	ØØ = OK, Ø1 = animal shot twice, Ø2 = questionable velocity

*Field content item printed-out in subsequent tables of this appendix.
**In those cases where information is not presently available, -1 has been used as a temporary indicator.

TABLE B-II

SUPERBALL II

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
1.	2.	298.0	11.6	1.	-1.00	1.	0.80	1.	3.	3.	-1.	-1.	-1.	-1.	-1.
2.	2.	285.0	11.6	1.	-1.00	2.	0.00	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
3.	2.	279.0	11.6	1.	-1.00	2.	0.00	2.	2.	0.	-1.	-1.	-1.	-1.	-1.
4.	2.	287.0	11.6	1.	-1.00	2.	0.00	2.	2.	0.	-1.	-1.	-1.	-1.	-1.
5.	2.	288.0	11.6	1.	-1.00	2.	0.00	3.	2.	0.	-1.	-1.	-1.	-1.	-1.
6.	2.	297.0	11.6	1.	-1.00	2.	0.00	3.	2.	0.	-1.	-1.	-1.	-1.	-1.
7.	2.	414.0	11.6	1.	-1.00	2.	0.00	1.	3.	1.	-1.	-1.	-1.	-1.	-1.
8.	2.	410.0	11.6	1.	-1.00	2.	1.00	1.	3.	4.	-1.	-1.	-1.	-1.	-1.
9.	2.	406.0	11.6	1.	-1.00	2.	0.00	2.	1.	1.	-1.	-1.	-1.	-1.	-1.
10.	2.	248.0	11.6	1.	-1.00	2.	0.00	2.	3.	0.	-1.	-1.	-1.	-1.	-1.
11.	2.	401.0	11.6	1.	-1.00	2.	0.00	3.	1.	0.	-1.	-1.	-1.	-1.	-1.
12.	2.	411.0	11.6	1.	-1.00	2.	0.80	3.	4.	3.	-1.	-1.	-1.	-1.	-1.
13.	2.	491.0	11.6	1.	-1.00	2.	1.00	1.	5.	5.	-1.	-1.	-1.	-1.	-1.
14.	2.	491.0	11.6	1.	-1.00	2.	1.00	1.	5.	5.	-1.	-1.	-1.	-1.	-1.
15.	2.	489.0	11.6	1.	-1.00	2.	1.00	2.	5.	5.	-1.	-1.	-1.	-1.	-1.
16.	2.	491.0	11.6	1.	-1.00	2.	1.00	2.	5.	5.	-1.	-1.	-1.	-1.	-1.
17.	2.	481.0	11.6	1.	-1.00	2.	0.20	3.	2.	1.	-1.	-1.	-1.	-1.	-1.
18.	2.	486.0	11.6	1.	-1.00	2.	0.80	3.	5.	3.	-1.	-1.	-1.	-1.	-1.
19.	2.	291.0	11.6	2.	-1.00	2.	0.00	8.	1.	-1.	0.	0.	0.	0.	0.
20.	2.	286.0	11.6	2.	-1.00	2.	0.00	8.	1.	-1.	0.	0.	0.	0.	0.
21.	2.	406.0	11.6	2.	-1.00	2.	1.00	8.	5.	-1.	0.	1.	5.	0.	0.
22.	2.	403.0	11.6	2.	-1.00	2.	1.00	8.	5.	-1.	0.	1.	5.	0.	0.
23.	2.	483.0	11.6	2.	-1.00	2.	1.00	8.	5.	-1.	0.	1.	5.	0.	0.
24.	2.	484.0	11.6	2.	-1.00	2.	1.00	7.	5.	-1.	5.	1.	0.	0.	0.
25.	2.	483.0	11.6	2.	-1.00	2.	1.00	9.	5.	-1.	0.	1.	0.	4.	0.
26.	2.	490.0	11.6	2.	-1.00	2.	0.20	9.	5.	-1.	0.	1.	0.	4.	0.
27.	2.	404.0	11.6	2.	-1.00	2.	0.40	9.	3.	-1.	0.	1.	0.	2.	0.
28.	2.	413.0	11.6	2.	-1.00	2.	0.40	9.	3.	-1.	0.	1.	0.	3.	0.
29.	2.	276.0	11.6	2.	-1.00	2.	0.60	9.	2.	-1.	0.	1.	0.	3.	0.
30.	2.	284.0	11.6	2.	-1.00	2.	0.20	9.	2.	-1.	0.	1.	0.	1.	0.
31.	2.	283.0	11.6	2.	-1.00	2.	0.80	7.	2.	-1.	0.	3.	0.	0.	0.
32.	2.	490.0	11.6	2.	-1.00	2.	0.00	10.	5.	-1.	0.	0.	0.	0.	0.
33.	2.	423.0	11.6	2.	-1.00	2.	0.00	10.	3.	-1.	0.	0.	0.	0.	0.
34.	2.	292.0	11.6	2.	-1.00	2.	0.00	10.	1.	-1.	0.	0.	0.	0.	0.
35.	2.	378.0	11.6	2.	-1.00	2.	1.00	7.	3.	-1.	0.	5.	0.	0.	0.
36.	2.	486.0	11.6	2.	-1.00	1.	1.00	7.	3.	-1.	0.	5.	0.	0.	0.

TABLE B-III

SUPERBALL III & SUPERBALL I

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
37.	3.	193.0	11.5	2.	14.50	2.	0.00	8.	3.	-1.	0.	0.	0.	0.	0.
38.	3.	199.0	11.5	2.	13.60	3.	0.00	8.	2.	-1.	0.	0.	0.	0.	0.
39.	3.	191.0	11.5	2.	17.00	2.	0.00	8.	2.	-1.	0.	0.	0.	0.	0.
40.	3.	271.0	11.5	2.	13.40	2.	0.00	-1.	2.	-1.	0.	1.	0.	0.	0.
41.	3.	273.0	11.5	2.	19.50	2.	0.00	7.	1.	-1.	0.	1.	0.	3.	0.
42.	3.	265.0	11.5	2.	13.40	1.	1.00	7.	3.	-1.	5.	0.	0.	3.	0.
43.	3.	279.0	11.5	2.	13.40	2.	0.00	-1.	1.	-1.	0.	2.	0.	3.	0.
44.	3.	401.0	11.5	2.	13.20	1.	0.50	8.	1.	-1.	0.	0.	3.	2.	0.
45.	3.	397.0	11.5	2.	15.20	1.	1.00	7.	5.	-1.	4.	4.	0.	0.	0.
46.	3.	402.0	11.5	2.	14.80	2.	0.50	7.	3.	-1.	2.	2.	0.	0.	0.
47.	3.	399.0	11.5	2.	12.60	2.	0.25	7.	3.	-1.	3.	4.	0.	0.	0.
48.	3.	462.0	11.5	2.	18.20	2.	0.50	7.	3.	-1.	2.	4.	0.	0.	0.
49.	3.	457.0	11.5	2.	15.30	2.	1.00	7.	5.	-1.	4.	3.	0.	0.	0.
50.	3.	455.0	11.5	2.	15.90	2.	0.10	7.	3.	-1.	1.	3.	0.	0.	0.
51.	3.	462.0	11.5	2.	14.50	2.	0.25	7.	3.	-1.	4.	2.	0.	0.	0.
52.	3.	397.0	11.5	2.	16.00	2.	-1.00	7.	1.	-1.	0.	1.	0.	0.	0.
53.	3.	187.0	11.5	2.	14.80	2.	0.00	9.	1.	-1.	0.	0.	0.	0.	0.
54.	3.	192.0	11.5	2.	15.20	2.	0.00	9.	2.	-1.	0.	0.	0.	0.	0.
55.	3.	191.0	11.5	2.	15.10	2.	0.00	9.	1.	-1.	0.	0.	0.	0.	0.
56.	3.	195.0	11.5	1.	10.70	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
57.	3.	186.0	11.5	1.	10.60	2.	0.00	1.	1.	0.	-1.	-1.	-1.	-1.	-1.
58.	3.	184.0	11.5	1.	10.00	2.	0.00	1.	1.	0.	-1.	-1.	-1.	-1.	-1.
59.	3.	186.0	11.5	1.	10.60	2.	0.00	1.	2.	0.	-1.	-1.	-1.	-1.	-1.
60.	3.	186.0	11.5	1.	11.90	2.	0.00	1.	2.	0.	-1.	-1.	-1.	-1.	-1.
61.	3.	187.0	11.5	1.	10.90	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
62.	3.	190.0	11.5	1.	10.80	2.	0.00	1.	1.	0.	-1.	-1.	-1.	-1.	-1.
63.	1.	374.0	11.5	1.	-1.00	2.	-1.00	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
64.	1.	392.0	11.5	1.	-1.00	2.	-1.00	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
65.	1.	409.0	11.5	1.	-1.00	2.	-1.00	1.	4.	3.	-1.	-1.	-1.	-1.	-1.
66.	1.	424.0	11.5	1.	-1.00	2.	-1.00	1.	4.	3.	-1.	-1.	-1.	-1.	-1.

TABLE B-IV

STUN-BAG

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
67.	4.	120.0	198.9	1.	9.60	2.	0.80	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
68.	4.	58.0	197.9	1.	11.30	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
69.	4.	87.9	191.2	1.	-1.00	2.	0.20	1.	2.	1.	-1.	-1.	-1.	-1.	-1.
70.	4.	95.8	190.5	1.	12.20	2.	0.20	1.	3.	1.	-1.	-1.	-1.	-1.	-1.
71.	4.	63.9	192.5	1.	9.00	2.	0.00	1.	2.	0.	-1.	-1.	-1.	-1.	-1.
72.	4.	49.5	185.0	1.	7.70	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
73.	4.	90.5	191.5	1.	11.40	2.	1.00	1.	4.	0.	-1.	-1.	-1.	-1.	-1.
74.	4.	102.0	196.6	1.	8.30	2.	0.20	1.	2.	0.	-1.	-1.	-1.	-1.	-1.
75.	4.	109.0	195.9	1.	7.20	2.	0.50	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
76.	4.	109.0	191.9	1.	8.70	4.	0.75	1.	4.	1.	-1.	-1.	-1.	-1.	-1.
77.	4.	57.2	194.4	1.	12.80	2.	0.10	3.	2.	0.	-1.	-1.	-1.	-1.	-1.
78.	4.	62.0	192.5	1.	7.40	2.	0.75	3.	1.	3.	-1.	-1.	-1.	-1.	-1.
79.	4.	63.9	183.7	.	12.70	2.	0.10	3.	0.	1.	-1.	-1.	-1.	-1.	-1.
80.	4.	69.7	186.9	1.	7.30	2.	0.10	3.	0.	2.	-1.	-1.	-1.	-1.	-1.
81.	4.	102.0	198.2	1.	12.70	2.	0.50	3.	3.	0.	-1.	-1.	-1.	-1.	-1.
82.	4.	95.8	197.5	1.	11.50	2.	1.00	3.	3.	3.	-1.	-1.	-1.	-1.	-1.
83.	4.	120.0	194.6	1.	11.10	2.	0.50	3.	3.	2.	-1.	-1.	-1.	-1.	-1.
84.	4.	136.0	197.0	1.	9.10	2.	0.00	3.	0.	0.	-1.	-1.	-1.	-1.	-1.
85.	4.	42.5	191.8	1.	8.80	2.	0.00	2.	0.	0.	-1.	-1.	-1.	-1.	-1.
86.	4.	60.8	193.0	1.	8.00	2.	0.00	2.	2.	0.	-1.	-1.	-1.	-1.	-1.
87.	4.	60.8	187.4	1.	10.30	2.	0.00	2.	0.	1.	-1.	-1.	-1.	-1.	-1.
88.	4.	93.0	187.5	1.	14.00	2.	0.00	2.	0.	0.	-1.	-1.	-1.	-1.	-1.
89.	4.	95.8	189.7	1.	7.00	2.	0.25	2.	2.	1.	-1.	-1.	-1.	-1.	-1.
90.	4.	102.0	193.5	1.	9.60	2.	1.00	2.	4.	5.	-1.	-1.	-1.	-1.	-1.
91.	4.	123.0	192.5	1.	7.40	2.	0.25	2.	2.	2.	-1.	-1.	-1.	-1.	-1.
92.	4.	95.8	192.0	2.	12.30	2.	0.90	8.	2.	-1.	0.	2.	4.	0.	0.
93.	4.	59.1	190.2	2.	13.70	2.	0.10	8.	0.	-1.	0.	0.	1.	0.	2.
94.	4.	59.0	191.0	2.	15.60	2.	0.50	8.	1.	-1.	0.	0.	3.	0.	0.
95.	4.	85.2	189.8	2.	14.50	2.	1.00	8.	1.	-1.	0.	0.	4.	0.	0.
96.	4.	100.0	190.4	2.	13.70	3.	1.00	8.	0.	-1.	5.	0.	3.	0.	0.
97.	4.	102.0	192.3	2.	-1.00	2.	1.00	8.	2.	-1.	0.	0.	4.	0.	0.
98.	4.	95.8	192.2	2.	14.60	2.	0.75	9.	3.	-1.	0.	0.	0.	4.	0.
99.	4.	54.8	187.2	2.	15.70	2.	0.00	9.	1.	-1.	0.	0.	0.	0.	0.
100.	4.	59.0	193.0	2.	12.70	2.	0.75	9.	3.	-1.	0.	0.	3.	4.	0.
101.	4.	79.2	184.5	2.	13.60	2.	1.00	9.	1.	-1.	0.	0.	5.	0.	0.
102.	4.	109.5	187.6	2.	16.20	2.	1.00	9.	4.	-1.	0.	0.	0.	4.	0.
103.	4.	109.0	188.8	2.	14.10	2.	0.50	9.	4.	-1.	0.	0.	0.	0.	0.
104.	4.	85.2	192.5	2.	13.80	2.	1.00	7.	2.	-1.	0.	2.	4.	2.	0.

TABLE B-IV (CONT)

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
105.	4.	60.0	189.9	2.	13.10	1.	1.00	7.	2.	-1.	0.	2.	2.	0.	0.
106.	4.	81.4	191.0	2.	17.40	2.	1.00	7.	1.	-1.	0.	2.	4.	0.	0.
107.	4.	85.2	190.0	2.	13.20	2.	1.00	7.	3.	-1.	0.	2.	0.	0.	0.
108.	4.	95.7	189.8	2.	14.10	1.	1.00	7.	5.	-1.	0.	2.	0.	0.	0.
109.	4.	113.0	189.0	2.	13.10	1.	1.00	7.	4.	-1.	0.	2.	3.	0.	0.
110.	4.	67.8	186.5	2.	16.50	2.	0.50	11.	0.	-1.	0.	0.	0.	0.	2.
111.	4.	109.0	186.3	2.	13.50	2.	1.00	11.	3.	-1.	0.	0.	3.	0.	0.
112.	4.	96.0	190.6	2.	12.70	2.	0.00	11.	2.	-1.	0.	0.	0.	0.	0.
113.	4.	98.8	190.5	2.	15.20	2.	1.00	11.	3.	-1.	0.	0.	4.	0.	0.
114.	4.	109.0	184.4	2.	13.40	2.	0.50	11.	3.	-1.	0.	0.	0.	0.	2.
115.	4.	102.0	193.2	2.	13.10	2.	0.75	11.	2.	-1.	0.	2.	0.	0.	1.
116.	4.	102.0	191.2	2.	17.90	2.	0.25	10.	2.	-1.	0.	0.	0.	0.	0.

TABLE B-V

WATERBALL

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
117.	5.	95.6	264.0	1.	-1.00	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
118.	5.	97.7	268.0	1.	-1.00	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
119.	5.	97.5	264.0	1.	-1.00	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
120.	5.	119.7	265.0	1.	-1.00	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
121.	5.	122.5	268.0	1.	-1.00	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
122.	5.	78.0	264.0	1.	-1.00	2.	0.00	2.	3.	0.	-1.	-1.	-1.	-1.	-1.
123.	5.	97.2	264.0	1.	-1.00	2.	0.00	-1.	3.	0.	-1.	-1.	-1.	-1.	-1.
124.	5.	109.7	265.0	1.	-1.00	2.	0.00	2.	0.	0.	-1.	-1.	-1.	-1.	-1.
125.	5.	115.9	267.0	1.	-1.00	2.	0.50	2.	3.	0.	-1.	-1.	-1.	-1.	-1.
126.	5.	76.1	267.0	1.	-1.00	2.	0.50	-1.	2.	0.	-1.	-1.	-1.	-1.	-1.
127.	5.	96.5	264.0	1.	-1.00	2.	0.00	3.	0.	0.	-1.	-1.	-1.	-1.	-1.
128.	5.	96.7	264.0	1.	-1.00	2.	0.00	3.	2.	0.	-1.	-1.	-1.	-1.	-1.
129.	5.	102.2	266.[illegible]	1.	-1.00	2.	0.50	3.	2.	0.	-1.	-1.	-1.	-1.	-1.
130.	5.	110.5	26[illegible]	1.	-1.00	2.	0.00	3.	1.	0.	-1.	-1.	-1.	-1.	-1.
131.	5.	93.3	264.0	1.	-1.00	2.	0.00	4.	0.	0.	-1.	-1.	-1.	-1.	-1.
132.	5.	96.6	264.0	1.	-1.00	2.	0.00	4.	0.	0.	-1.	-1.	-1.	-1.	-1.
133.	5.	85.2	262.0	2.	-1.00	3.	0.10	7.	3.	0.	0.	0.	0.	0.	0.
134.	5.	86.7	263.0	2.	-1.00	2.	0.50	7.	1.	-1.	3.	1.	0.	0.	0.
135.	5.	87.0	264.0	2.	-1.00	1.	1.00	7.	0.	-1.	0.	1.	2.	0.	0.
136.	5.	87.2	263.0	2.	-1.00	2.	0.75	7.	2.	-1.	3.	2.	0.	0.	0.
137.	[illegible]	87.3	263.0	2.	-1.00	2.	1.00	7.	1.	-1.	0.	3.	0.	0.	0.
138.	5.	87.2	264.0	2.	-1.00	2.	0.00	-1.	0.	-1.	0.	0.	0.	0.	3.
139.	5.	94.4	264.0	2.	-1.00	3.	0.00	7.	1.	-1.	0.	0.	0.	0.	0.
140.	5.	101.3	264.0	2.	-1.00	1.	0.75	7.	1.	-1.	0.	2.	2.	0.	0.
141.	5.	101.5	264.0	2.	-1.00	2.	0.10	7.	2.	-1.	2.	0.	0.	0.	0.
142.	5.	101.5	264.0	2.	-1.00	2.	0.75	7.	1.	-1.	0.	3.	2.	0.	0.
143.	5.	105.0	264.0	2.	-1.00	1.	1.00	7.	2.	-1.	0.	2.	0.	0.	0.
144.	5.	109.1	264.0	2.	-1.00	1.	1.00	7.	3.	-1.	3.	2.	0.	0.	0.
145.	5.	52.3	261.0	2.	-1.00	2.	0.00	8.	0.	-1.	0.	0.	0.	0.	0.
146.	5.	54.2	260.0	2.	-1.00	2.	0.00	8.	0.	-1.	0.	0.	0.	0.	0.
147.	5.	61.3	260.0	2.	-1.00	2.	0.00	8.	0.	-1.	0.	0.	2.	0.	0.
148.	5.	82.8	262.0	2.	-1.00	2.	0.00	8.	1.	-1.	0.	0.	2.	0.	0.
149.	5.	84.9	262.0	2.	-1.00	2.	1.00	8.	1.	-1.	0.	0.	3.	0.	0.
150.	5.	85.8	262.0	2.	-1.00	2.	2.50	8.	2.	-1.	0.	0.	2.	0.	0.
151.	5.	87.5	262.0	2.	-1.00	2.	1.00	8.	1.	-1.	0.	0.	3.	0.	0.
152.	5.	90.9	262.0	2.	-1.00	1.	1.00	8.	1.	-1.	1.	3.	0.	0.	0.
153.	5.	100.7	262.0	2.	-1.00	1.	0.50	8.	1.	-1.	0.	3.	2.	0.	0.

TABLE B-V (CONT)

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
154.	5.	104.8	264.0	2.	-1.00	1.	1.00	8.	1.	-1.	0.	2.	3.	0.	0.
155.	5.	112.3	264.0	2.	-1.00	2.	1.00	9.	2.	-1.	0.	3.	3.	0.	0.
156.	5.	56.8	262.2	2.	-1.00	3.	0.00	9.	0.	-1.	0.	0.	0.	0.	0.
157.	5.	57.5	262.2	2.	-1.00	3.	0.00	9.	0.	-1.	0.	0.	0.	0.	0.
158.	5.	56.8	261.0	2.	-1.00	3.	0.30	9.	0.	-1.	0.	0.	0.	0.	0.
159.	5.	85.0	263.0	2.	-1.00	2.	0.22	9.	0.	-1.	0.	0.	0.	0.	0.
160.	5.	86.3	263.0	2.	-1.00	2.	0.25	9.	0.	-1.	0.	0.	0.	0.	0.
161.	5.	86.5	263.0	2.	-1.00	2.	0.00	9.	0.	-1.	0.	0.	0.	3.	0.
162.	5.	91.1	266.0	2.	-1.00	2.	0.00	9.	1.	-1.	0.	0.	0.	0.	1.
163.	5.	91.6	266.2	2.	-1.00	4.	-1.00	9.	1.	-1.	0.	0.	0.	1.	0.
164.	5.	102.6	265.0	2.	-1.00	2.	0.00	9.	1.	-1.	0.	0.	0.	0.	0.

TABLE B-VI

PING PONG BALL

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
165.	6.	188.9	30.0	1.	-1.00	2.	0.00	3.	0.	0.	-1.	-1.	-1.	-1.	-1.
166.	6.	189.0	29.0	1.	-1.00	2.	0.00	3.	1.	0.	-1.	-1.	-1.	-1.	-1.
167.	6.	252.2	29.0	1.	-1.00	5.	-1.00	3.	2.	0.	-1.	-1.	-1.	-1.	-1.
168.	6.	254.7	31.0	1.	-1.00	2.	0.00	3.	2.	0.	-1.	-1.	-1.	-1.	-1.
169.	6.	294.6	30.0	1.	-1.00	1.	1.00	3.	2.	4.	-1.	-1.	-1.	-1.	-1.
170.	6.	305.0	29.0	1.	-1.00	2.	0.20	1.	1.	0.	-1.	-1.	-1.	-1.	-1.
171.	6.	191.9	30.0	1.	-1.00	1.	1.00	2.	0.	1.	-1.	-1.	-1.	-1.	-1.
172.	6.	195.7	30.0	1.	-1.00	5.	0.00	2.	1.	0.	-1.	-1.	-1.	-1.	-1.
173.	6.	269.3	30.0	1.	-1.00	2.	0.00	2.	1.	0.	-1.	-1.	-1.	-1.	-1.
174.	6.	245.3	33.0	1.	-1.00	2.	1.00	2.	2.	3.	-1.	-1.	-1.	-1.	-1.
175.	6.	306.5	29.0	1.	-1.00	3.	-1.00	2.	1.	0.	-1.	-1.	-1.	-1.	-1.
176.	6.	309.7	29.0	1.	-1.00	2.	0.75	2.	3.	2.	-1.	-1.	-1.	-1.	-1.
177.	6.	187.2	30.0	1.	-1.00	3.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
178.	6.	193.0	30.0	1.	-1.50	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
179.	6.	256.6	30.0	1.	-1.00	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
180.	6.	256.9	29.0	1.	-1.00	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
181.	6.	284.8	29.0	1.	-1.00	3.	0.50	1.	2.	0.	-1.	-1.	-1.	-1.	-1.
182.	6.	290.3	31.0	1.	-1.00	3.	-1.00	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
183.	6.	292.3	30.0	1.	-1.00	2.	1.00	1.	3.	4.	-1.	-1.	-1.	-1.	-1.
184.	6.	295.1	31.0	1.	-1.00	2.	0.75	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
185.	6.	287.0	28.0	1.	-1.00	3.	-1.00	4.	2.	0.	-1.	-1.	-1.	-1.	-1.
186.	6.	309.0	28.0	1.	-1.00	2.	1.00	4.	3.	0.	-1.	-1.	-1.	-1.	-1.
187.	6.	166.7	32.0	2.	-1.00	2.	0.25	7.	2.	-1.	1.	1.	0.	0.	0.
188.	6.	169.5	30.0	2.	-1.00	2.	0.00	7.	2.	-1.	0.	2.	0.	0.	0.
189.	6.	183.5	30.0	2.	-1.00	2.	0.00	7.	2.	-1.	0.	0.	0.	0.	0.
190.	6.	191.2	31.0	2.	-1.00	1.	1.00	7.	1.	-1.	2.	2.	0.	0.	0.
191.	6.	230.2	29.0	2.	-1.00	1.	1.00	7.	1.	-1.	1.	1.	0.	0.	0.
192.	6.	231.0	29.0	2.	-1.00	1.	1.00	7.	1.	-1.	0.	1.	0.	0.	0.
193.	6.	236.9	29.0	2.	-1.00	1.	1.00	7.	1.	-1.	0.	1.	0.	0.	0.
194.	6.	240.2	30.0	2.	-1.00	2.	1.00	7.	3.	-1.	0.	5.	0.	0.	0.
195.	6.	293.0	30.0	2.	-1.00	2.	1.00	7.	3.	-1.	5.	3.	0.	0.	0.
196.	6.	293.6	30.0	2.	-1.00	1.	1.00	7.	3.	-1.	3.	2.	0.	0.	0.
197.	6.	306.8	30.0	2.	-1.00	1.	1.00	7.	2.	-1.	5.	4.	0.	0.	0.
198.	6.	309.7	30.0	2.	-1.00	1.	1.00	7.	4.	-1.	3.	3.	0.	0.	0.
199.	6.	294.1	31.0	2.	-1.00	2.	1.00	10.	4.	-1.	5.	0.	0.	0.	0.
202.	6.	294.3	31.0	2.	-1.00	4.	1.00	10.	4.	-1.	0.	0.	0.	0.	0.

TABLE B-VI (CONT)

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PVE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
201	6.	182.9	30.0	2.	-1.00	1.	0.75	8.	1.	-1.	2.	0.	2.	0.	0.
202.	6.	184.3	30.0	2.	-1.00	1.	1.00	8.	1.	-1.	2.	0.	3.	0.	0.
203.	6.	184.6	30.0	2.	-1.00	1.	1.00	8.	2.	-1.	4.	3.	3.	0.	0.
204.	6.	192.8	28.0	2.	-1.00	1.	1.00	8.	1.	-1.	3.	3.	0.	0.	0.
205.	6.	247.7	30.0	2.	-1.00	1.	1.00	8.	2.	-1.	0.	1.	2.	0.	0.
206.	6.	252.3	30.0	2.	-1.00	1.	1.00	8.	3.	-1.	0.	2.	3.	0.	0.
207.	6.	254.4	30.0	2.	-1.00	2.	1.00	8.	3.	-1.	2.	0.	3.	0.	0.
208.	6.	256.8	30.0	2.	-1.00	1.	1.00	[illegible]	3.	-1.	0.	0.	4.	0.	0.
209.	6.	275.9	31.0	2.	-1.00	1.	1.00	8.	2.	-1.	0.	0.	5.	0.	0.
210.	6.	296.3	31.0	2.	-1.00	1.	1.00	8.	5.	-1.	0.	0.	5.	0.	0.
211.	6.	796.6	29.0	2.	-1.00	1.	1.00	8.	5.	-1.	0.	0.	2.	0.	5.
212.	6.	180.7	29.0	2.	-1.00	5.	1.00	9.	3.	-1.	3.	0.	0.	4.	0.
213.	6.	185.0	29.0	2.	-1.00	5.	1.00	9.	4.	-1.	0.	0.	0.	4.	0.
214.	6.	192.5	29.0	2.	-1.00	3.	1.00	9.	3.	-1.	3.	0.	0.	4.	0.
215.	6.	194.0	29.0	2.	-1.00	3.	1.00	9.	3.	-1.	3.	0.	0.	4.	0.
216.	6.	238.0	30.0	2.	-1.00	1.	1.00	9.	2.	-1.	0.	0.	0.	4.	0.
217.	6.	255.8	30.0	2.	-1.00	2.	1.00	9.	3.	-1.	0.	0.	0.	4.	0.
218.	6.	260.9	30.0	2.	-1.00	2.	1.00	9.	4.	-1.	0.	0.	0.	5.	0.
219.	6.	261.5	29.0	2.	1.00	2.	1.00	9.	4.	-1.	0.	0.	0.	5.	0.
220.	6.	292.5	29.0	2.	-1.00	5.	1.00	9.	4.	-1.	0.	0.	0.	5.	0.
221.	6.	298.9	30.0	2.	-1.00	2.	1.00	9.	4.	-1.	0.	0.	0.	5.	0.
222.	6.	301.7	29.0	2.	-1.00	5.	1.00	9.	2.	-1.	0.	0.	0.	5.	0.

TABLE B-VII

PAINTBALL

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
223.	7.	538.3	3.2	1.	12.25	2.	0.25	3.	3.	0.	-1.	-1.	-1.	-1.	-1.
224.	7.	551.4	3.2	1.	11.79	2.	0.00	3.	2.	0.	-1.	-1.	-1.	-1.	-1.
225.	7.	717.1	3.2	1.	11.34	2.	1.00	3.	5.	2.	-1.	-1.	-1.	-1.	-1.
226.	7.	745.1	3.2	1.	10.89	5.	-1.00	-1.	0.	0.	-1.	-1.	-1.	-1.	-1.
227.	7.	884.5	3.2	1.	11.34	2.	1.00	3.	2.	2.	-1.	-1.	-1.	-1.	-1.
228.	7.	886.5	3.2	1.	11.79	2.	0.00	-1.	2.	0.	-1.	-1.	-1.	-1.	-1.
229.	7.	519.2	3.2	1.	11.34	2.	1.00	2.	5.	4.	-1.	-1.	-1.	-1.	-1.
230.	7.	540.5	3.2	1.	10.43	3.	0.50	2.	2.	1.	-1.	-1.	-1.	-1.	-1.
231.	7.	734.0	3.2	1.	10.89	2.	1.00	2.	5.	4.	-1.	-1.	-1.	-1.	-1.
232.	7.	798.0	3.2	1.	11.34	2.	1.00	2.	3.	4.	-1.	-1.	-1.	-1.	-1.
233.	7.	867.3	3.2	1.	10.89	2.	1.00	2.	5.	4.	-1.	-1.	-1.	-1.	-1.
234.	7.	868.0	3.2	1.	11.79	2.	0.50	2.	4.	1.	-1.	-1.	-1.	-1.	-1.
235.	7.	531.9	3.2	1.	10.43	2.	0.25	1.	3.	2.	-1.	-1.	-1.	-1.	-1.
236.	7.	557.2	3.2	1.	10.43	3.	0.90	1.	1.	3.	-1.	-1.	-1.	-1.	-1.
237.	7.	733.1	3.2	1.	11.79	2.	-1.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
238.	7.	736.6	3.2	1.	12.25	2.	0.25	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
239.	7.	574.1	3.2	1.	9.98	2.	1.00	1.	5.	5.	-1.	-1.	-1.	-1.	-1.
240.	7.	877.5	3.2	1.	10.43	1.	1.00	1.	5.	5.	-1.	-1.	-1.	-1.	-1.
241.	7.	963.7	3.2	1.	12.25	2.	1.00	1.	5.	5.	-1.	-1.	-1.	-1.	-1.
242.	7.	920.3	3.2	1.	10.89	2.	1.00	1.	5.	3.	-1.	-1.	-1.	-1.	-1.
243.	7.	887.3	3.2	1.	13.15	2.	1.00	4.	3.	0.	-1.	-1.	-1.	-1.	-1.
244.	7.	899.5	3.2	1.	10.89	2.	1.00	4.	4.	0.	-1.	-1.	-1.	-1.	-1.
245.	7.	530.0	3.2	2.	10.43	2.	0.00	7.	2.	-1.	0.	0.	0.	0.	0.
246.	7.	530.9	3.2	2.	15.42	2.	0.10	7.	2.	-1.	0.	2.	0.	0.	0.
247.	7.	536.1	3.2	2.	10.89	2.	1.00	7.	5.	-1.	0.	2.	0.	0.	0.
248.	7.	551.7	3.2	2.	10.89	2.	1.00	7.	5.	-1.	0.	3.	0.	0.	0.
249.	7.	733.4	3.2	2.	9.07	2.	1.00	7.	5.	-1.	3.	3.	0.	0.	0.
250.	7.	739.9	3.2	2.	14.06	2.	1.00	7.	5.	-1.	0.	4.	0.	0.	0.
251.	7.	749.6	3.2	2.	10.43	1.	1.00	7.	5.	-1.	4.	4.	0.	0.	0.
252.	7.	752.4	3.2	2.	14.51	2.	1.00	7.	5.	-1.	0.	5.	0.	0.	0.
253.	7.	877.5	3.2	2.	9.53	2.	1.00	7.	5.	-1.	0.	5.	0.	0.	0.
254.	7.	881.4	3.2	2.	14.97	1.	1.00	7.	5.	-1.	3.	3.	0.	0.	0.
255.	7.	886.9	3.2	2.	11.79	2.	1.00	7.	5.	-1.	0.	4.	0.	0.	0.
256.	7.	892.0	3.2	2.	13.61	2.	1.00	7.	5.	-1.	0.	4.	0.	0.	0.
257.	7.	530.6	3.2	2.	9.07	2.	1.00	8.	5.	-1.	0.	0.	4.	0.	0.
258.	7.	543.7	3.2	2.	11.34	2.	1.00	8.	5.	-1.	0.	0.	0.	0.	0.
259.	7.	548.0	3.2	2.	14.52	2.	1.00	8.	5.	-1.	0.	0.	0.	0.	0.
260.	7.	744.0	3.2	2.	9.98	2.	1.00	8.	5.	-1.	3.	2.	0.	0.	0.

TABLE B-VII (CONT)

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
261.	7.	750.1	3.2	2.	11.79	2.	1.00	8.	5.	-1.	0.	0.	4.	0.	0.
262.	7.	750.4	3.2	2.	12.25	2.	1.00	8.	5.	-1.	0.	5.	0.	0.	0.
263.	7.	873.3	3.2	2.	10.43	2.	1.00	8.	5.	-1.	0.	0.	5.	0.	5.
264.	7.	807.7	3.2	2.	11.79	5.	1.00	8.	5.	-1.	0.	0.	4.	0.	0.
265.	7.	902.1	3.2	2.	11.79	1.	1.00	8.	5.	-1.	0.	0.	5.	0.	0.
266.	7.	-1.0	3.2	2.	9.98	2.	1.00	9.	5.	-1.	0.	0.	0.	0.	4.
267.	7.	534.0	3.2	2.	8.62	2.	0.75	-1.	3.	-1.	0.	0.	0.	0.	0.
268.	7.	537.3	3.2	2.	12.25	2.	0.75	9.	3.	-1.	0.	0.	0.	0.	0.
269.	7.	549.1	3.2	2.	10.43	2.	1.00	9.	5.	-1.	0.	0.	0.	2.	0.
270.	7.	749.6	3.2	2.	9.98	1.	1.00	9.	5.	-1.	0.	0.	0.	3.	0.
271.	7.	742.3	3.2	2.	12.25	2.	1.00	9.	5.	-1.	0.	0.	0.	2.	5.
272.	7.	874.1	3.2	2.	9.98	2.	1.00	9.	5.	-1.	0.	0.	0.	3.	0.
273.	7.	896.8	3.2	2.	8.16	2.	1.00	9.	5.	-1.	0.	0.	0.	4.	5.
274.	7.	919.1	3.2	2.	11.79	2.	1.00	9.	5.	-1.	0.	0.	0.	5.	0.
275.	7.	897.2	3.2	2.	17.24	5.	1.00	10.	5.	-1.	0.	0.	0.	0.	0.
276.	7.	918.2	3.2	2.	16.78	2.	1.00	10.	5.	-1.	0.	0.	0.	0.	0.

TABLE B-VIII

RICOCHET ROUND

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
277.	8.	318.5	8.2	1.	12.25	2.	0.00	3.	0.	0.	-1.	-1.	-1.	-1.	-1.
278.	8.	326.2	8.2	1.	15.88	2.	0.00	3.	2.	0.	-1.	-1.	-1.	-1.	-1.
279.	8.	453.6	8.2	1.	-1.00	2.	0.10	3.	2.	1.	-1.	-1.	-1.	-1.	-1.
280.	8.	474.9	8.2	1.	13.61	2.	0.90	3.	3.	4.	-1.	-1.	-1.	-1.	-1.
281.	8.	587.3	8.2	1.	-1.00	2.	1.00	3.	3.	3.	-1.	-1.	-1.	-1.	-1.
282.	8.	587.7	8.2	1.	-1.00	2.	1.00	3.	5.	4.	-1.	-1.	-1.	-1.	-1.
283.	8.	310.8	8.2	1.	13.15	2.	0.10	2.	1.	1.	-1.	-1.	-1.	-1.	-1.
284.	8.	353.0	8.2	1.	11.34	2.	1.00	2.	1.	4.	-1.	-1.	-1.	-1.	-1.
285.	8.	442.8	8.2	1.	9.98	2.	1.00	2.	5.	5.	-1.	-1.	-1.	-1.	-1.
286.	8.	470.4	8.2	1.	-1.00	2.	1.00	2.	5.	5.	-1.	-1.	-1.	-1.	-1.
287.	8.	556.4	8.2	1.	-1.00	2.	1.00	2.	5.	5.	-1.	-1.	-1.	-1.	-1.
288.	8.	559.1	8.2	1.	-1.00	2.	1.00	2.	5.	5.	-1.	-1.	-1.	-1.	-1.
289.	8.	572.9	8.2	1.	12.70	2.	1.00	2.	5.	4.	-1.	-1.	-1.	-1.	-1.
290.	8.	324.5	8.2	1.	11.79	2.	0.10	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
291.	8.	367.3	8.2	1.	10.43	2.	-1.00	1.	4.	0.	-1.	-1.	-1.	-1.	-1.
292.	8.	445.0	8.2	1.	-1.00	2.	0.10	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
293.	8.	452.8	8.2	1.	12.70	2.	1.00	1.	5.	4.	-1.	-1.	-1.	-1.	-1.
294.	8.	457.3	8.2	1.	-1.00	2.	1.90	1.	5.	3.	-1.	-1.	-1.	-1.	-1.
295.	8.	535.7	8.2	1.	-1.00	2.	1.00	1.	5.	5.	-1.	-1.	-1.	-1.	-1.
296.	8.	606.4	8.2	1.	-1.00	2.	1.00	1.	5.	5.	-1.	-1.	-1.	-1.	-1.
297.	8.	308.8	8.2	2.	11.34	2.	0.75	7.	2.	-1.	0.	2.	0.	0.	0.
298.	8.	312.7	8.2	2.	5.44	1.	1.00	7.	2.	-1.	1.	5.	0.	0.	0.
299.	8.	329.8	8.2	2.	8.62	2.	0.10	7.	2.	-1.	0.	1.	0.	0.	0.
300.	8.	349.1	8.2	2.	14.97	2.	0.50	7.	2.	-1.	0.	2.	0.	0.	0.
301.	8.	445.3	8.2	2.	7.71	1.	0.00	7.	4.	-1.	2.	4.	0.	0.	3.
302.	8.	466.3	8.2	2.	14.52	2.	1.00	7.	5.	-1.	0.	3.	0.	0.	0.
303.	8.	472.2	8.2	2.	11.34	2.	1.00	7.	5.	-1.	0.	5.	0.	0.	0.
304.	8.	474.3	8.2	2.	17.24	2.	0.50	7.	3.	-1.	0.	3.	0.	0.	0.
305.	8.	553.4	8.2	2.	8.16	1.	1.00	7.	5.	-1.	0.	5.	0.	0.	0.
306.	8.	559.2	8.2	2.	8.16	1.	1.00	7.	5.	-1.	3.	5.	0.	0.	0.
307.	8.	561.6	8.2	2.	11.34	1.	1.00	7.	5.	-1.	5.	5.	0.	0.	0.
308.	8.	561.7	8.2	2.	9.98	1.	1.00	7.	5.	-1.	5.	5.	0.	0.	0.
309.	8.	582.2	8.2	2.	14.97	2.	1.00	10.	5.	-1.	0.	0.	0.	0.	0.
310.	8.	587.0	8.2	2.	14.97	2.	1.00	10.	5.	-1.	0.	0.	0.	0.	0.
311.	8.	-1.0	8.2	2.	8.62	2.	1.00	8.	3.	-1.	0.	0.	4.	0.	0.
312.	8.	278.4	8.2	2.	14.97	2.	1.00	8.	3.	-1.	0.	0.	4.	0.	0.
313.	8.	313.4	8.2	2.	8.16	2.	1.00	8.	2.	-1.	0.	0.	4.	0.	0.
314.	8.	454.4	8.2	2.	11.34	5.	1.00	8.	5.	-1.	3.	3.	4.	0.	0.

TABLE B-VIII (CONT)

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PVE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
315.	8.	461.0	8.2	2.	14.97	2.	1.00	8.	3.	-1.	0.	0.	4.	0.	3.
316.	8.	465.7	8.2	2.	14.52	2.	1.00	8.	5.	-1.	0.	0.	4.	0.	0.
317.	8.	556.4	8.2	2.	11.79	1.	1.00	8.	5.	-1.	0.	0.	5.	0.	0.
318.	8.	557.2	8.2	2.	1 .06	1.	1.00	8.	5.	-1.	0.	0.	5.	0.	0.
319.	8.	566.7	8.2	2.	10.43	1.	1.00	8.	5.	-1.	0.	0.	5.	0.	0.
320.	8.	286.6	8.2	2.	11.79	2.	0.10	7.	2.	-1.	3.	3.	6.	0.	0.
321.	8.	320.6	8.2	2.	19.05	2.	0.00	9.	3.	-1.	0.	0.	0.	0.	0.
322.	8.	326.0	8.2	2.	9.98	2.	0.10	9.	2.	-1.	0.	0.	0.	1.	0.
323.	8.	453.4	8.2	2.	16.33	2.	0.25	9.	3.	-1.	0.	0.	0.	0.	0.
324.	8.	455.8	8.2	2.	16.33	2.	0.25	9.	3.	-1.	0.	0.	0.	0.	0.
325.	8.	462.3	8.2	2.	14.06	2.	0.25	9.	4.	-1.	0.	0.	0.	1.	0.
326.	8.	545.7	8.2	2.	13.61	2.	1.00	9.	5.	-1.	0.	0.	0.	5.	0.
327.	8.	562.2	8.2	2.	14.06	1.	1.00	-1.	5.	-1.	0.	0.	0.	0.	5.
328.	8.	581.7	8.2	2.	10.89	1.	1.00	9.	5.	-1.	0.	0.	0.	5.	0.

TABLE B-IX

RTV ROUND

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
329.	9.	220.0	17.0	1.	10.43	2.	0.00	3.	1.	0.	-1.	-1.	-1.	-1.	-1.
330.	9.	220.0	17.0	1.	14.97	2.	0.00	3.	0.	0.	-1.	-1.	-1.	-1.	-1.
331.	9.	230.0	17.0	1.	9.07	2.	0.00	3.	0.	0.	-1.	-1.	-1.	-1.	-1.
332.	9.	384.0	17.0	1.	14.52	2.	0.00	3.	0.	0.	-1.	-1.	-1.	-1.	-1.
333.	9.	355.0	17.0	1.	12.70	2.	0.00	3.	0.	0.	-1.	-1.	-1.	-1.	-1.
334.	9.	375.0	17.0	1.	13.61	2.	0.00	3.	2.	5.	-1.	-1.	-1.	-1.	-1.
335.	9.	384.0	17.0	1.	12.25	2.	1.00	3.	3.	3.	-1.	-1.	-1.	-1.	-1.
336.	9.	230.0	17.0	1.	9.98	2.	0.00	2.	0.	0.	-1.	-1.	-1.	-1.	-1.
337.	9.	236.0	17.0	1.	10.43	2.	0.00	2.	0.	0.	-1.	-1.	-1.	-1.	-1.
338.	9.	230.0	17.0	1.	10.43	2.	0.10	2.	2.	0.	-1.	-1.	-1.	-1.	-1.
339.	9.	322.0	17.0	1.	9.53	2.	0.10	2.	2.	0.	-1.	-1.	-1.	-1.	-1.
340.	9.	346.0	17.0	1.	9.07	2.	1.00	2.	2.	3.	-1.	-1.	-1.	-1.	-1.
341.	9.	375.0	17.0	1.	9.07	3.	0.00	2.	1.	0.	-1.	-1.	-1.	-1.	-1.
342.	9.	432.0	17.0	1.	8.62	2.	1.00	2.	2.	3.	-1.	-1.	-1.	-1.	-1.
343.	9.	231.0	17.0	1.	13.61	2.	0.00	1.	3.	0.	-1.	-1.	-1.	-1.	-1.
344.	9.	231.0	17.0	1.	9.98	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
345.	9.	231.0	17.0	1.	10.87	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
346.	9.	288.0	17.0	1.	9.07	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
347.	9.	262.0	17.0	1.	9.07	2.	0.25	1.	5.	0.	-1.	-1.	-1.	-1.	-1.
348.	9.	366.0	17.0	1.	9.07	4.	0.10	1.	2.	0.	-1.	-1.	-1.	-1.	-1.
349.	9.	354.0	17.0	1.	9.07	2.	0.00	1.	0.	0.	-1.	-1.	-1.	-1.	-1.
350.	9.	374.0	17.0	1.	11.79	2.	0.50	1.	3.	1.	-1.	-1.	-1.	-1.	-1.
351.	9.	242.0	17.0	2.	19.05	1.	1.00	7.	1.	-1.	0.	5.	0.	0.	0.
352.	9.	230.0	17.0	2.	17.24	2.	0.00	7.	1.	-1.	0.	0.	0.	0.	0.
353.	9.	190.1	17.0	2.	17.69	2.	0.00	7.	2.	-1.	0.	1.	0.	0.	0.
354.	9.	230.0	17.0	2.	9.98	2.	0.00	7.	0.	-1.	0.	0.	0.	0.	0.
355.	9.	224.0	17.0	2.	14.52	2.	0.00	7.	2.	-1.	0.	0.	0.	0.	0.
356.	9.	250.0	17.0	2.	14.97	3.	0.25	7.	2.	-1.	0.	2.	0.	0.	0.
357.	9.	355.0	17.0	2.	17.69	5.	0.25	7.	2.	-1.	0.	2.	0.	0.	0.
358.	9.	346.0	17.0	0.	5.90	5.	1.00	7.	1.	-1.	0.	5.	0.	0.	0.
359.	9.	354.0	17.0	2.	9.98	1.	1.00	7.	1.	-1.	2.	3.	0.	0.	0.
360.	9.	346.0	17.0	2.	16.33	1.	1.00	7.	3.	-1.	2.	2.	0.	0.	0.
361.	9.	375.0	17.0	2.	14.97	5.	1.00	7.	5.	-1.	3.	2.	0.	0.	0.
362.	9.	420.0	17.0	2.	12.25	5.	0.25	7.	2.	-1.	0.	3.	0.	0.	0.
363.	9.	406.4	17.0	2.	17.24	2.	0.00	7.	2.	-1.	0.	1.	0.	0.	0.
364.	9.	432.0	17.0	2.	16.78	3.	1.00	7.	5.	-1.	0.	0.	0.	0.	0.
365.	9.	256.0	17.0	2.	14.06	2.	0.00	8.	1.	-1.	0.	0.	0.	0.	0.

TABLE B-IX (CONT)

RECORD NUMBER	TEST ITEM	PROJ. VEL. F/S	PROJ. WT. G	ANIMAL SPECIE	ANIMAL WEIGHT KG	DEATH QUALI-FIER	PUE	TARGET AREA HIT	SSM GRADE	HEAD GRADE	HEART GRADE	LUNG GRADE	LIVER GRADE	KIDNEY GRADE	OTHER VISCERA GRADE
366.	9.	243.0	17.0	2.	14.52	5.	0.00	8.	1.	-1.	0.	0.	0.	0.	0.
367.	9.	243.0	17.0	2.	15.88	2.	0.00	8.	1.	-1.	0.	0.	0.	0.	0.
368.	9.	308.0	17.0	2.	16.78	2.	1.00	8.	1.	-1.	2.	2.	0.	0.	0.
369.	9.	338.0	17.0	2.	10.43	1.	1.00	8.	5.	-1.	0.	2.	3.	0.	0.
370.	9.	355.0	17.0	2.	12.70	1.	1.00	8.	2.	-1.	3.	2.	0.	6.	0.
371.	9.	356.0	17.0	2.	15.88	2.	1.00	8.	3.	-1.	0.	0.	5.	0.	0.
372.	9.	384.0	17.0	2.	12.70	2.	0.50	8.	3.	-1.	0.	0.	2.	0.	0.
373.	9.	420.0	17.0	2.	14.97	2.	1.00	8.	5.	-1.	3.	2.	0.	0.	0.
374.	9.	235.0	17.0	2.	7.26	5.	0.00	9.	2.	-1.	6.	0.	1.	0.	0.
375.	9.	249.0	17.0	2.	13.15	5.	0.00	9.	1.	-1.	0.	0.	0.	0.	0.
376.	9.	261.0	17.0	2.	6.80	1.	1.00	9.	3.	-1.	0.	0.	0.	4.	0.
377.	9.	288.0	17.0	2.	20.87	2.	0.00	9.	2.	-1.	0.	6.	0.	0.	0.
378.	9.	288.0	17.0	2.	15.42	2.	0.00	9.	2.	-1.	0.	0.	0.	0.	0.
379.	9.	364.0	17.0	2.	8.16	3.	0.25	9.	3.	-1.	0.	0.	0.	0.	0.
380.	9.	355.0	17.0	2.	10.89	2.	0.50	9.	3.	-1.	0.	2.	0.	2.	0.
381.	9.	364.0	17.0	2.	14.52	2.	0.75	9.	3.	-1.	0.	0.	0.	2.	0.
382.	9.	374.0	17.0	2.	16.33	2.	0.50	-1.	3.	-1.	0.	0.	0.	1.	0.
383.	9.	308.0	17.0	2.	11.79	3.	0.25	10.	3.	-1.	0.	0.	0.	0.	0.
384.	9.	376.0	17.0	2.	9.53	2.	0.25	10.	3.	-1.	0.	0.	0.	0.	0.

APPENDIX C

DAMAGE LEVEL GRADES GROUPED BY KINETIC ENERGY FOR THE AREA HIT ONLY

The damage grades utilized in this appendix are grouped according to kinetic-energy bands; for example, the kinetic-energy level 15 represents all kinetic energies 0 through 15 ft-lb, 30 represents 16 through 30 ft-lb, etc. Additionally, the damage grades consider only the area/organ impacted and do not include other areas/organs which may have been affected by the impact. For example, if the projectile impacted the liver (the designated target area) and the kidney also received damage from the impact, then, for the purpose of this appendix, only the liver damage was considered when grouping the data.

It should be noted that an attempt was made to verify the projectile's velocity and associated kinetic energy for each shot through the analysis of high-speed films. There were, however, a few instances where the film was not available and the original chronograph readings were then utilized. These cases are indicated in the appropriate matrices by asterisks.

As a final comment, for the matrices entitled "Head (Skin)", the numbers outside the parentheses include only the head (brain-skull) area, and the numbers within the parentheses include only the skin of the head.

TABLE C-I. SUPERBALL (I, II & III)

Thorax

Lung

DL								
5				1			1	
4					2	1		
3			1			2		
2					1	1		
1		2			1			
0					1			
KE (ft-lb)	15	30	45	60	75	90	105	120

Heart

DL								
5		1					1	
4					1	2		
3		1			2			
2						2		
1								
0		3			2			
KE (ft-lb)	15	30	45	60	75	90	105	120

Liver

DL								
5					2		1	
4								
3					1			
2								
1								
0	3		2					
KE (ft-lb)	15	30	45	60	75	90	105	120

Kidney

DL								
5								
4							1	
3		1			1			
2					1		1	
1			1					
0	3							
KE (ft-lb)	15	30	45	60	75	90	105	120

Body Skin

DL								
5					3	1	5	
4								
3	1	1		1	5	3	1	
2	3	1	2					
1	2	1	3		2			
0								
KE (ft-lb)	15	30	45	60	75	90	105	120

Head (Skin)

DL								
5							4(5)	
4					1(3)			
3		(1)	1(2)	(1)	3(3)		1	
2	(2)	(1)	(3)				(1)	
1	(3)				2(2)		1	
0	7(2)	2	4	1	2			
KE (ft-lb)	15	30	45	60	75	90	105	120

TABLE C-II. STUN-BAG

Thorax

DL	Lung							
5								
4								
3								
2		1	1	3		1		
1								
0								
KE ft-lb	15	30	45	60	75	90	105	120

DL	Heart							
5								
4								
3								
2								
1								
0		1	1	3		1		
KE ft-lb	15	30	45	60	75	90	105	120

DL	Liver							
5								
4				2	1			
3		1			1			
2		1						
1		1						
0								
KE ft-lb	15	30	45	60	75	90	105	120

DL	Kidney							
5								
4		1		1		1		
3								
2								
1								
0		1	1			1		
KE ft-lb	15	30	45	60	75	90	105	120

DL	Body Skin							
5				1				
4						3		
3		1		2	3			
2		1		3	3			
1		2	2	1				
0		2			1			
KE ft-lb	15	30	45	60	75	90	105	120

DL	Head (Skin)								
5					1				
4				(1)	(1)	(1)			
3		1		1(2)	(1)	(1)	(1)		
2		(3)	1	(2)	(1)		2(1)		
1		2(1)		3		1			
0	2(2)	4(3)	(1)	2(1)	2	1	1(1)		1(1)
KE ft-lb	15	30	45	60	75	90	105	120	135

TABLE C-III. WATERBALL

Thorax

Lung(s)

DL								
5								
4								
3					1		1	
2					1		2	1
1					2			
0					2	1		
KE ft-lb	15	30	45	60	75	90	105	120

Heart

DL								
5								
4								
3					2			1
2							1	
1								
0					3	1	3	
KE ft-lb	15	30	45	60	75	90	105	120

Liver

DL								
5								
4								
3					2		1	1
2			1	1	1		1	
1								
0		2			1			
KE ft-lb	15	30	45	60	75	90	105	120

Kidney

DL								
5								
4								
3					1			
2								
1					1			
0		2	1		2	1	1	
KE ft-lb	15	30	45	60	75	90	105	120

Body Skin

DL								
5								
4								
3					1			1
2					2		2	1
1				1	6	2	5	
0		4	2		4			
KE ft-lb	15	30	45	60	75	90	105	120

Head (Skin)

DL										
5										
4										
3									(1)	
2							(1)			
1								(1)		
0				1(1)		7(7)	1	2(1)	2(1)	1(1)
KE ft-lb	15	30	45	60	75	90	105	120	135	150

TABLE C-IV. PING PONG BALL

Thorax

DL	Lung							
5				1				
4							1	
3						1	1	
2		1	1			1		
1		1		3				
0			1					
KE (ft-lb)	15	30	45	60	75	90	105	120

DL	Heart							
5						1	2	
4								
3						1		
2			1					
1		1		1				
0		1	1	3				
KE (ft-lb)	15	30	45	60	75	90	105	120

DL	Liver							
5						1	1	
4					1			
3			2		2			
2			1		1	1		
1								
0			1					
KE (ft-lb)	15	30	45	60	75	90	105	120

DL	Kidney							
5					2	2	1	
4			4	1	1			
3								
2								
1								
0								
KE (ft-lb)	15	30	45	60	75	90	105	120

DL	Body Skin							
5						2		
4			1		2	1	4	
3			3	1	4	2		
2		2	2	1	1	2	1	
1			4	3				
0								
KE (ft-lb)	15	30	45	60	75	90	105	120

DL	Head (Skin)							
5								
4						2		
3					1	(2)	(3)	
2					(3)	(3)	1	
1			1([illegible])		(1)		(2)	
0			5(4)		5(2)	3	4	
KE (ft-lb)	15	30	45	60	75	90	105	120

TABLE C-V. PAINTBALL

Thorax

Lung

DL								
5					1	1		
4				1	1	2		
3			1	1		1		
2		1	1					
1								
0		1						
KE (ft-lb)	15	30	45	60	75	90	105	120

Heart

DL								
5								
4					1			
3				1		1		
2								
1								
0		2	2	1	1	3		
KE (ft-lb)	15	30	45	60	75	90	105	120

Liver

DL								
5						2		
4		1			1	1		
3								
2								
1								
0			2		2			
KE (ft-lb)	15	30	45	60	75	90	105	120

Kidney

DL								
5							1	
4						1		
3					1	1		
2			1	1				
1								
0			1	1				
KE (ft-lb)	15	30	45	60	75	90	105	120

Body Skin

DL								
5		1	5	5	5	10	2	
4								
3			1					
2		2						
1								
0								
KE (ft-lb)	15	30	45	60	75	90	105	120

Head (Skin)

DL								
5		(1)		(2)		3(4)	(1)	
4		1		1	1	1(2)		
3			1(2)	(1)	(1)	(1)	1	
2			1(2)	1		1(1)		
1			1(1)			1		
0			2	2(1)		2		
KE (ft-lb)	15	30	45	60	75	90	105	120

TABLE C-VI. RICOCHET ROUND

Thorax

Lung

DL								
5		1			1	4		
4				1				
3		1			2			
2		1	1					
1		1						
0								
KE ft-lb	15	30	45	60	75	90	105	120

Heart

DL								
5						2		
4								
3		1				1		
2				1				
1		1						
0		2	1		3	1		
KE ft-lb	15	30	45	60	75	90	105	120

Liver

DL								
5						3		
4		3		2	1			
3								
2								
1								
0								
KE ft-lb	15	30	45	60	75	90	105	120

Kidney

DL								
5						1	1	
4								
3								
2								
1		1		1				
0		1		2				
KE ft-lb	15	30	45	60	75	90	105	120

Body Skin

DL								
5				1	3	8	3	
4				2				
3		3		3	1			
2		6	1					
1								
0								
KE ft-lb	15	30	45	60	75	90	105	120

Head (Skin)

DL								
5				1(3)	1(1)	3(3)	1(3)	
4			1(1)	1	1		2	
3		(1)		1(1)	(1)		1(1)	
2		(1)		(1)				
1		1(1)	(1)	1				
0		3(1)	1	1				
KE ft-lb	15	30	45	60	75	90	105	120

TABLE C-VII. RTV ROUND

Thorax

DL	Lung							
5			1		1			
4								
3					1		1	
2			1		2	1		
1		1					1*	
0		3						1
KE (t-1b)	15	30	45	60	75	90	105	120

DL	Heart							
5								
4								
3						1		
2					2			
1								
0		4	2		2		2*	1
KE (t-1b)	15	30	45	60	75	90	105	120

DL	Liver							
5					1			
4								
3					1			
2						1		
1								
0			3	1	1		1	
KE (t-1b)	15	30	45	60	75	90	105	120

DL	Kidney							
5								
4			1					
3								
2					1	1		
1								
0			2	2		1		
KE (t-1b)	15	30	45	60	75	90	105	120

DL	Body Skin							
5					1	1	1	1
4								
3			1	1	3	4		
2		2*	2	2	2		2	
1		1	5	1	2			
0		1						
KE (t-1b)	15	30	45	60	75	90	105	120

DL	Head (Skin)							
5								
4								
3			(1)	(1)	1	1(2)		1
2		(1)		(1)	(1)	(2)		(1)
1		(1)				1(1)		
0		5(3)	4(3)	3(1)	2(2)	4(1)		
KE (t-1b)	15	30	45	60	75	90	105	120